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Forthcoming Events.

SEPTEMBER 5.

Institution of British Foundrymen (Lancashire Branch):—Visit to Messrs. R. & J. Dempster, Limited, at Manchester.

SEPTEMBER 9-11.

Iron and Steel Institute:—Autumn meeting at Birmingham.

SEPTEMBER 10.

Institute of British Foundrymen (London Section):—Inaugural meeting in London. Presidential address. "What is Wrong with our Industry," by G. C. Pierce.

SEPTEMBER 12.

Institute of British Foundrymen (Lancashire Branch Junior Section):—Visit to Stanton Ironworks Company, near Derby.

SEPTEMBER 14.

Society of Engineers:—Summer visit to General Omnibus Company, Limited, at Chiswick.

SEPTEMBER 21-28.

Cycle and Motor Show, at Olympia, London.

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES EQUIPMENT AND SUPPLIES ASSOCIATION.

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The Dusseldorf Foundry Exhibition.

This Exhibition, which remains open until September 13, is undoubtedly the largest and best foundry exhibition which has ever been staged in Europe. There are 1,500 iron foundries in Germany, and 1,442 of them belong to the Iron Foundry Owners' Association, who are responsible for the organisation of the 4th German Foundry Exhibition. Put crudely, this Association is, *inter alia*, a price-fixing ring, the prices being based upon a standardised system of costing. Naturally, the railway companies and other large buyers are constantly objecting to the prices charged by the foundries, and by means of this Exhibition the foundry owners have very cleverly—by means of a technical exhibit—justified their costing system and consequently the prices asked. *The Trust can and does justify itself to the public by the research work it conducts and the technical development it encourages.* It is these technical exhibits housed in the central hall which made the strongest appeal to the party of British visitors which spent last week-end in the Exhibition. One which attracted considerable attention was a miniature casting in the form of a weight, and with it were proportional heaps of coke, pig-iron, scrap, sand, limestone and every other material which has to be transported in the foundry during its manufacture. It made an impressive appeal for the intensive study of the transport problem. The history of the cupola, an exhibit designed by Dr. Geilenkirchen, traced the development of the early furnace right up to the latest German method utilising pre-heated blast. The development of the moulding machine was similarly dealt with. A striking exhibit was that which showed the lay-out of about 60 representative German foundries. We received the impression that German foundry owners feel that they are not up to date so far as foundry transport is concerned, and that they intend emulating the Americans in this respect. The model foundry, which is housed in a separate building, utilises a "creeping" conveyor system, a method which appeals to us as minimising troubles arising from damp sand in bearings. The cupola selected for this department was mechanically charged, and a water spray system was incorporated for the elimination of dust and spark troubles. Amongst the novelties we noted was a vibrating finger for the cleaning out of cores from small pipe bends and the like: a sand blast helmet which was provided with a light tubular rim, connected with a compressed air supply—this curtain of air-draught effectually prevented flying grit from reaching the operator's face; high-pressure water for cleaning castings, a system which has been tried out by Mr. Charles Markham, of Chesterfield—is also being exploited.

The sand-slinging method of moulding was shown by the German firm handling the Beardsley-Piper system, whilst a second system (Prosama) was also being demonstrated.

On the "Perlit" iron stand there were several excellent specimens made by the North Eastern Marine Engineering Company, Limited, demonstrating the malleable properties of the alloy. The well-known firm of Gutmann had an excellent exhibit of sand blast machines, whilst the moulding machines of Zimmerman, the Badische concern of Durlach, Leber and Bröse and Kritschmer can be considered as typical of modern practice.

Several firms showed a horizontal type of ladle, but whilst we really fail to appreciate the outstanding advantages of this type, we can easily envisage its drawbacks. A very nice friction-

driven tumbling barrel by a Rheinland firm was generally favourably commented upon.

Some of the machines seemed of rather more heavy design than would appear necessary. An oil core-sand mixer had in one case developed into a quite complicated mechanism comparable with a universal multiple drilling machine. We imagine it would cost twice as much as the best one could buy from a British manufacturer.

One technical exhibit was misunderstood by some of the British visitors. It related to internal costing, and a diagram of every production movement was connected by a tape to the various forms used for the collection of costing data. The system appeared to be very complicated, but the idea was to give a graphic demonstration with the sole object of simplification.

The buyers of German castings could not help being impressed by a diagram made up of five curves of the actual ascertained costs of several types of castings made in four different works plotted against the unified system, *which was practically central*.

We strongly recommend as many British foundrymen as possible to visit the Düsseldorf Exhibition. If they have the good fortune to have the technical exhibits explained to them in detail they would return impressed by the necessity to form in Great Britain a strong commercial organisation capable of evolving and instituting a justifiable unified costing system for the whole of the British foundries.

Repairing a Copper Tank.

BY "VALLISHE."

It is seldom that one comes across an easy and really satisfactory method of repairing a copper tank or cylinder when it has ceased to be water-tight. After years of use, sometimes coupled with

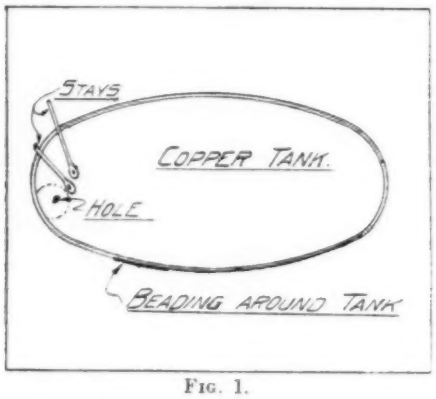

FIG. 1.

rough usage, a copper tank is apt to become thin in places, or may break out into a small hole. Now, in the latter case soldering is not always effective, this depending on the nature of the contents of the tank. In the case of an auto-

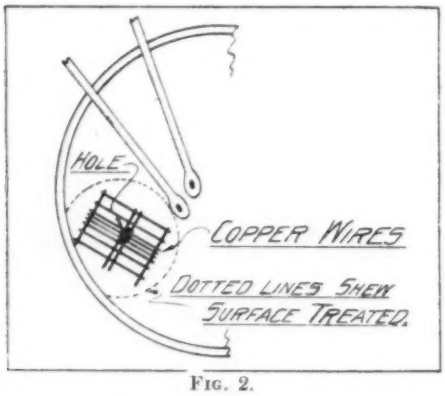

FIG. 2.

mobile petrol tank, the writer was asked to inspect the tank of a 45-h.p. Daimler car. The owner of the car had been in a minor accident, resulting in a leaky petrol tank. On inspection the tank was found to be of copper, the leakage being from a small hole at the side of the tank and very close to the supporting bracket. The car was taken to a garage, and here the tank was soldered. This proved to be an utter failure, and the same method was tried again, but with little or no more success than before. A tinner advised a new tank, but this meant an outlay of several pounds. Being far from satisfied, the writer decided to try the following experiment: Fig. 1 shows a side elevation of the tank and the approximate position of the hole. The side of the tank was thoroughly cleaned and scraped, and then rubbed over with a piece of fine sandpaper. The surface round the hole (the hole was about $\frac{1}{8}$ in. dia.) for a radius of two to three inches was thus treated. A rough round file was then applied with a medium touch. Some good thick commercial gum was then rubbed all over the surface and then several pieces of $\frac{1}{16}$ in. dia. copper wire, each about $1\frac{1}{2}$ in. long, were cut. These were placed on the tank as illustrated in Fig. 2, the gum, of course, holding them in their place. The gum was then allowed to dry for about ten or fifteen minutes. Best quality *iron* cement (no other kind of cement proved satisfactory on account of the searching properties of petroleum; several brands of iron cement are guaranteed to resist petroleum and several acids) was then mixed with a few drops of water, to the consistency of putty. This was then applied to the desired place with a palette knife to a thickness of about $\frac{1}{2}$ in. by about 2 in. in diameter. All rough corners were smoothed off, the thickness gradually tapering off to nothing at the sides. The cement was then left to dry, this taking roughly about one and a half hours. When thoroughly set the cement is of a very hard nature indeed, and should be closely inspected, any rough corners being taken off with a file. The surface should then be coated with shellac, this helping to make the surface entirely weatherproof.

The result was highly satisfactory. There are fewer sounder tests than the constant bumping and vibration that occurs when the car is on the road, but in this case the repair was completely satisfactory. This method, of course, could be applied to all forms of tanks or cylinders, whether copper or not, and though it may not prove to be a permanent repair, it will last for quite a considerable time under ordinary conditions. The writer has also applied this method with advantage to an automobile radiator.

Catalogues Received.

Patents.—Messrs. King's Patent Agency, Limited, of 146, Queen Victoria Street, E.C.4, and 6, Quality Court, Chancery Lane, W.C.2, have prepared a folder emphasising the desirability of people protecting their inventions and, in addition, offering to send along a handbook dealing with this subject.

Electric Resistances Furnaces. — Of special interest to foundrymen is the four-page pamphlet (D) issued by the Electric Furnace Company, of 17, Victoria Street, London, S.W.1. After outlining the advantages of electricity as a fuel, the pamphlet points out that the more modern type demands no static transformers. One of the principal applications dealt with is that of vitreous enamelling, where absence of dust and large output per unit of floor space are of special interest. Another sphere of interest for the resistance furnace is annealing. The uses for this type of furnace are numerous, and no catalogue, however comprehensive, could quite cover the field, and each problem has to be specially dealt with. In this direction the Electric Furnace Company have the advantage of being in a position to draw upon the large practical experience gained by the Automatic and Electric Furnaces, Limited, and the George J. Hagan Company, of Pittsburg.

Ladders. — A four-leaf folder received from Messrs. Hall, Phillipson & Company, Limited, of 32, Victoria Street, London, S.W.1, indicates that they are introducing to the British market a special safety bracket which prevents the slipping of the ladder and holds the user some 14 in. away from the wall. The brackets are secured to top of the legs of the ladder, and when fixed have a span of 42 in.

THE INSTITUTE OF METALS.

AUTUMN MEETING IN GLASGOW.

The autumn meeting of the Institute of Metals was held during the current week in Glasgow under the presidency of Professor Thomas Turner. The Rankine Hall was placed at the disposal of the Institute by courtesy of the Institution of Engineers and Shipbuilders in Scotland. On Tuesday Sir John Dewrance, K.B.E., a Vice-President of the Institute, gave the Fourth Autumn Lecture, taking for his subject "Education, Research and Standardisation."

Over two hundred members and friends were present at the opening session on Wednesday. In the afternoon visits were paid to the following works:—The Albion Motor Company, Limited, Babcock & Wilcox, Limited; The Fairfield Shipbuilding and Engineering Company, Limited; The North British Locomotive Company, Limited; and G. & J. Weir, Limited. The Lord-Provost, Magistrates, and Corporation of Glasgow gave a reception to the visitors in the evening, for which some 800 invitations had been sent out.

This morning (Thursday) there was a further session for the reading of Papers, whilst this afternoon the visitors are sailing down the industrial portion of the Clyde, followed by a smoking concert in the evening. To-morrow the visitors are to visit the Trossachs and Loch Lomond. The reception committee, presided over by Lord Weir of Eastwood, are to be congratulated on the success of their work, and in particular the thanks of the visitors are due to Mr. H. H. A. Greer, the honorary secretary of this committee, on whose shoulders fell the bulk of the work.

SIR JOHN DEWRANCE, K.B.E.

Sir John Dewrance, who read the Autumn Lecture at the autumn meeting of the Institute of Metals, is a Vice-President of the Institute, and is also President of the British Cast Iron Research Association. He is chairman of Babcock & Wilcox, Limited, and of the firm of Dewrance & Company, Great Dover Street. Additionally, he presides over the Committee responsible for the research on non-ferrous alloys now being carried out at the National Physical Laboratory.

Below we give some lengthy abstracts of the Papers of definite interest to foundrymen, while those of more academic interest are summarised. The work of ascertaining the properties of various alloys at elevated temperatures and practical tests on the nature of corrosion are subjects of the highest importance, and foundrymen are advised to keep themselves closely in touch with these developments so that they can anticipate improvements in the products which have eventually to withstand these conditions.

The Institute will find much in Glasgow of great practical interest. So far as Great Britain is concerned, it is the centre for Monel metal. The educational authorities of the district have provided excellent facilities for the teaching of, and research upon, metals. Indeed, the papers submitted show conclusively that Glasgow is doing excellent work in the investigation of the nature of industrial alloys.

The Properties of Some Aluminium Alloys.

BY HARRY HYMAN, Ph.D. (Glasgow).

[ABRIDGED.]

The increasing use of aluminium alloys for engineering purposes has emphasised the desirability of a metal possessing good mechanical properties and capable of giving sound castings in sand-moulds. The number of alloys available at the present time is very limited. These are generally characterised by the low elongation they give under test, many of them being entirely devoid of this property. It is true that this lack of ductility may in certain cases be of little consequence in the conditions under which they are subsequently used. In their actual manufacture, however, difficulties inevitably arise. Owing to their brittleness, they cannot be handled with freedom in the machine shops. They are liable to fracture under sudden shock, and break readily under rough usage. If off-size, they cannot readily be sprung when forcing them to shape.

Should the alloys form part of the apparatus on board ship a use to which they are being increasingly applied—the choice of a suitable metal becomes further restricted. When exposed to sea-spray conditions many aluminium alloys suffer rapid corrosion, and this is especially the case when in contact with other metals.

Copper and zinc are the metals most generally employed for alloying with aluminium. The former metal, although improving the tensile strength, has a deleterious effect on the ductility, while it has been generally established that the use of zinc is unsuitable when the alloy is exposed to corrosive influences.

The object of these experiments was the preparation of an alloy which would give good mechanical tests when cast in sand-moulds, and at the same time be resistant to atmospheric and sea-spray conditions. From experience of the tests given by alloys generally employed for sand castings, it was decided to fix minimum values of 5 tons per sq. in. yield point, 10 tons per sq. in. tensile strength, and 5 per cent. elongation. It was considered that if these figures could be maintained, a step would be taken in the right direction towards the production of an alloy suitable for general engineering requirements.

The minimum, and not the average, figures should be considered of prime importance in fixing the limitations of an alloy for any specific pur-

pose. Unless an alloy can be depended upon to pass certain minimum tests, it can under no circumstances be considered reliable for any mechanism of which it may form a part.

In previous researches on light alloys too much stress has been placed on the values obtained on chill-cast bars. As the bulk of these alloys are used for sand castings, and as these are gradually taking the place of the heavier alloys, it is very desirable to have data on their properties when cast in sand. The values resulting from heat-treatment should also be obtained from bars cast under those conditions. The high figures obtained by the heat treatment of chilled and wrought bars are apt to be misleading, and no such process can be of great value unless applicable to castings made in sand moulds.

A considerable amount of work has been done on the important binary alloys of aluminium, and their equilibrium diagrams have been closely investigated by various experimenters. Much work has yet to be done in the case of the ternary and higher alloys. In this research, an alloy of aluminium, copper, nickel, and iron has been made the basis of experiment. The field of quaternary alloy investigations being so large, it is hoped that the researches in this limited area will be of some interest to those engaged in the scientific development of the light alloys.

Preparation of the Alloys.

The selection of the quaternary alloy mentioned was the result of economic conditions in the foundry rather than of theoretical considerations. A rich alloy of copper, nickel, and iron has been used for a considerable time for the manufacture of manganese brass. This alloy (Z16), obtained by melting together copper, nickel, and iron, had the following composition :—Copper, 75: nickel, 15: and iron, 10 per cent.

The melting point of the alloy being too high for direct solution in aluminium, an intermediary alloy or hardener (A3) of the following composition was prepared :—Aluminium, 50.0: copper, 37.5: nickel, 7.5: and iron, 5.0 per cent.:

By means of this alloy, copper, nickel, and iron in the above proportions can be readily introduced into aluminium.

It was considered advisable to try the effect of 3 per cent. of copper, thus necessitating the introduction of 8 per cent. of the hardener. By using these percentages an alloy of the following theoretical composition would be obtained :—Aluminium, 96.0: copper, 3.0: nickel, 0.6: and iron, 0.4 per cent.

The hardener was placed at the bottom of the crucible and heated until molten. The aluminium was added gradually, allowed to melt, and the contents well stirred. The pot was withdrawn, carefully skimmed, and a small piece of magnesium, equivalent to 0.1 per cent., plunged by means of an iron rod under the surface of the metal. The contents were again stirred and poured into ingots, the total weight being about 70 lbs. The ingots were re-melted and poured into test-bars in green-sand moulds. These were machined down to the dimensions given in Fig. 1, the original diameter being 0.675 in. In all cases two test-bars were cast, the figures obtained being the average of those results. If precautions are taken to keep the surface of the metal clean, duplicate results very closely agreeing can be obtained. Should any inclusion, however, be entrapped in the test-bar, fracture almost invariably takes place at that spot, with a correspondingly low elongation. The bars were broken on a 10-ton Buckton self-recording tensile testing machine.

The pouring temperature was in all cases 680 to 700 deg. C., the measurements being taken by immersing a base metal thermocouple below the surface of the molten alloy. This couple was calibrated from time to time against a standard.

Owing to the fact that commercial aluminium always contains a small percentage of iron and other impurities, and that a small loss of the ingredients occurs in the melting operations, the resultant alloy shows some variations from the theoretical one. An analysis of the alloy prepared in the manner described gave the following figures :—Aluminium, 94.58: copper, 3.17: nickel 0.58: iron, 0.76: magnesium, 0.10: and silicon, 0.81 per cent.

The mechanical results obtained from this alloy were low, showing only 8.6 tons per sq. in. tensile strength and 2 to 3 per cent. elongation.

By increasing the copper percentage the tensile strength was slightly increased at the expense of the elongation; but the further addition of iron gave promising results. Accordingly, a series of alloys were prepared in which the copper and nickel were kept constant and the iron increased to about 3 per cent. This additional iron was introduced by means of an aluminium-iron hardener (Z14) containing 20 per cent. of iron.

The composition of these alloys, together with the results obtained, is given in Table I.

TABLE I.—*Effect of Iron on Aluminium Alloy containing Copper 3.0 per cent., Nickel 0.6 per cent., Magnesium 0.1 per cent. Sand-Cast Test-Bar Results*

Mark.	Composition. Per cent.						Mechanical Properties.			
	Al.	Cu.	Ni.	Fe.	Mg.	Si.	Yield-point in Tons per sq. in.	Breaking stress in Tons per sq. in.	Elongation. Per cent. on 2 in.	Hardness (Scleroscope).
BS2	94.58	3.17	0.58	0.76	0.10	0.81	6.0	8.6	2.3	13
BS16	93.98	3.02	0.58	1.57	0.09	0.76	4.8	11.1	7.9	12
BS7	93.88	2.89	0.62	1.75	0.10	0.76	4.8	11.3	8.0	12
BS17	93.53	2.95	0.59	2.03	0.10	0.80	5.6	11.0	8.3	12
BS9	93.12	3.14	0.60	2.29	0.10	0.75	5.2	11.3	5.6	13
BS19	93.18	2.90	0.58	2.45	0.10	0.79	4.6	10.4	6.3	12
BS8	92.52	3.09	0.63	2.91	0.09	0.76	6.4	9.1	2.5	13

A gradual improvement in properties takes place up to about 2 per cent. iron, after which a diminution occurs. From these alloys BS7 was selected for further detailed examination. This was considered the most likely one to be of any use for production on a commercial scale for engineering purposes.

The Properties of the Alloy BS7.

This alloy was adopted for general use in the foundry, and many castings of various sizes and shapes have been made from it. It behaves like the aluminium alloys generally in use, but has a tendency to shrink slightly more than the average. Difficulties in this respect only arise in certain types of castings, but these can be overcome by a judicious use of risers and chills. The metal should be poured fairly slowly and at a low temperature. This is in the neighbourhood of 700 deg. C., and depends on the size and complexity of the mould.

Its melting point is 640 deg. C. and its specific gravity 2.80.

In the foundry practice a large number of routine test-bars have been broken from time to time. In some cases they were attached to castings. The following results were obtained :—

Yield point. Tons per sq. in.		Maximum stress. Tons per sq. in.		Elongation. Per cent. on 2 in.		Hardness (Scleroscope).	
Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
4	5.5	10	11.5	5	8.5	12	14

With ordinary care minimum figures of 4 tons per sq. in. yield point, 10 tons per sq. in. tensile strength, and 5 per cent. elongations can be readily obtained.

Effect of Remelting.

The changes undergone during the remelting of aluminium alloys are not yet definitely understood, and in this connection it may be of interest to record the results obtained by the continuous remelting of this alloy. For this purpose 70 lbs. were melted, two test-bars made, and the remainder poured into ingots. The ingots, together with the gates and risers from the test-bars,

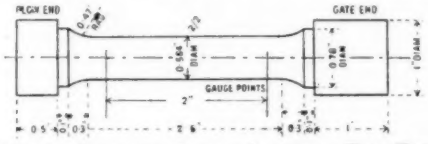

FIG. 1.—BARR AND STROUD STANDARD TEST-BAR.

were remelted and poured into two more test-bars, the surplus metal being again ingoted. This process was repeated six times, and the results are given in Table II.

TABLE II.—*Effect of Remelting Alloy BS7. Sand-Cast Test-Bar Results.*

	Yield point. Tons per sq. in.	Breaking stress. Tons per sq. in.	Elongation. Per cent. on 2 in.	Hardness (Scleroscope).
As cast	4.4	11.1	6.0	13
1st remelt ..	4.8	11.3	8.0	12
2nd ,, ...	4.8	10.9	7.2	13
3rd ,, ...	4.7	10.7	6.8	12
4th ,, ...	4.5	10.7	5.9	13
5th ,, ...	5.0	10.6	6.0	13
6th ,, ...	4.2	10.8	7.6	13

It is seen that the first remelt causes an improvement in properties, after which the figures remain quite steady. It is therefore advisable, when preparing this alloy to pour it into ingots, and use these for casting purposes.

At this stage two test-bars of a proprietary aluminium silcion alloy, the properties of which have received much prominence of late, were broken. These bars were attached to castings. The following results were obtained :—

	Yield point. Tons per sq. in.	Breaking stress. Tons per sq. in.	Elongation. Per cent. on 2 in.	Hardness (Scleroscope).	Fracture.
(1)	4.8	9.2	2.5	14	Spongy
(2)	5.2	11.2	10.0	14	Silky

From the fractures it appeared that the modifying process so essential to the manufacture of this alloy had in the case of (1) not been properly carried out. The high temperature used in the process renders the material very liable to a defect of this kind. In the case of (2), the elongation is slightly more than that of BS7. The latter has the advantage that no modifying process requiring superheating of the metal and additional time for flux reactions is necessary for its preparation. The material in the form of ingots can be employed in the usual manner for the manufacture of castings.

Shrinkage Tests.

These tests were undertaken to observe the actual shrinkage of the alloy when cooling from the liquid state. Rods of metal 1 in. square and 12 in. long were cast in green-sand moulds between the faces of a steel template. When cool the contractions were measured. These gave mean values of 0.17 in. per ft. The usual allowance for 4 per cent. copper, 12 per cent. zinc alloy, is 0.15 in. per ft.

Fatigue Tests.

As no general relation has been established between the yield point or breaking stress and the fatigue strength of aluminium alloys, it was considered desirable to carry out an independent investigation on this alloy. For comparative purposes two other alloys, lettered Z and N, were put through similar tests. Z, an alloy much in use for sand castings, contained 4 per cent. copper and 12 per cent. zinc, while N was a proprietary alloy, sold as possessing the property of high resistance to corrosion.

These tests were carried out on the fatigue testing apparatus devised by Dr. Haigh. Five pieces were employed in each series. Different stresses were used for each piece, and the range of stress was maintained constant throughout each individual test. The frequency was 2,000 cycles per minute for all the tests, and the stresses alternated between equal values of pull and push. The figures quoted below are the stress values in tons per sq. in.—*i.e.*, only half the corresponding ranges of stress. The endurances are given in millions of cycles required to cause fracture. In one case a test piece had not broken after nearly six million cycles, when the test was discontinued.

The results are given in Table III.

The set of observations for the BS7 series plots is a very fair graph, indicating that the metal is homogeneous, and therefore reliable. It appears that the fatigue limit may be taken as at least 6.0, fully half of the tensile ultimate—a very satisfactory ratio.

In the N series only one piece falls far short, while four others fall very close to, but slightly below, the smooth graph for BS7. We may infer that N is nearly as good as BS7, for one faulty piece is never enough to condemn a metal in fatigue tests.

The points in the Z series do not plot so well as for BS7. While some of the points are nearly as high as for BS7, others fall far short of the smooth graph. No blowholes or inclusions were present which would account for this irregularity.

Corrosion Tests.

In order to observe the ability of the alloy to withstand corrosion, a series of tests were carried out in which rectangular plates were subjected to the influence of ordinary atmospheric conditions. As large numbers of aluminium castings are ultimately used on board ship, and thus exposed to the effects of sea-water spray, systematic tests were also carried out in which plates were subjected to an artificial salt-water spray. For comparative purposes plates of other alloys were put through the same tests. The plates were cast in sand moulds, and their dimensions were approximately 12.5 × 6.0 × 0.25 cm. Some had their surfaces smoothed by grinding on a carborundum wheel.

TABLE III.—*Fatigue Test Results on Sand-Cast Test-Bars.*

BS7	Fatigue stress ..	9.5	8.5	7.5	7.0	6.5	
	Endurance	0.128	0.400	0.774	1.668	5.7127	Unbroken
Z	Fatigue stress ..	9.5	8.0	7.0	6.0	6.0	
	Endurance	0.120	0.548	0.436	0.230	0.780	Broke
N	Fatigue stress ..	9.5	9.0	8.5	8.0	6.5	
	Endurance ..	0.018	0.102	0.210	0.340	0.546	Broke

The alloys used are given in Table IV.

TABLE IV.—*Alloys Used in Corrosion Tests.*

BS7.

N. An anti-corrosive proprietary alloy. Same as used in fatigue tests.

Y. The National Physical Laboratory "Y" alloy, containing 4 per cent. copper, 2 per cent. nickel, and 1.5 per cent. magnesium.

Z. Contains 4 per cent. copper and 12 per cent. zinc.

The corrosion of all light alloys is influenced considerably by contact with other metals. As such composite structures are quite common in engineering practice, tests were carried out with a view to observing the effect of these metals. For this purpose several plates had screws of brass, phosphor bronze, and steel fixed into them, and subjected to the same corrosion tests.

The arrangement of the screws is shown in Fig. 2.

In the ordinary atmospheric test, plates of BS7 and N alloys, with and without screws, were suspended to the branches of a tree in a country district a few miles from Glasgow. At the end of five months their surfaces became slightly dull, but no signs of corrosion were evident. The steel

screws, however, were badly rusted. The plates were weighed, before and after exposure, and in no case did any loss in weight occur.

In the artificial salt-water spray test the plates were drilled near the top end to allow a nickel-plated ¼ in. diameter brass rod to pass through, and suspended in a sheet iron rectangular bath with tightly-fitting closed lid. The dimensions and arrangements for producing the spray are illustrated in Fig. 3.

Water containing 5 per cent. by weight of salt was introduced to a depth of about 3 in. Air under pressure was admitted into the tubes A,

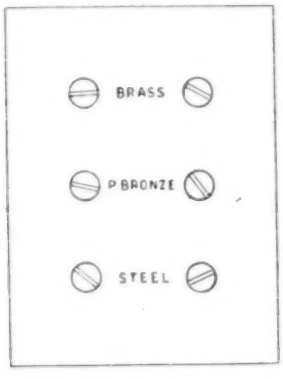

FIG. 2.—ARRANGEMENT OF SCREWS FOR CORROSION TESTS.

which terminated in small nozzles. By means of the suction produced the salt-water was drawn up the tubes B, at the ends of which nozzles were also attached. A fine spray was thus formed which completely filled the bath. The spray was allowed to act for nine hours during the day and turned off overnight. The plates were thus subjected to corrosive influences much more severe than would occur under ordinary atmospheric conditions, and their behaviour would therefore be comparable to what would take place under

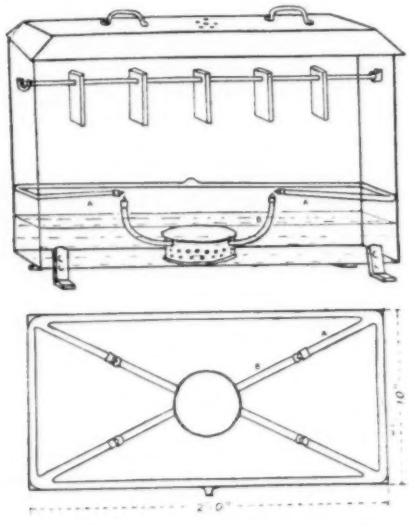

FIG. 3.—SALT-WATER SPRAY CORROSION APPARATUS.

normal conditions, but at longer intervals. They were withdrawn after fortnightly periods, scrubbed with a coarse-fibred brush, and dried at 200 deg. C. They were further scrubbed with a wire brush to remove any deposit not firmly adhering and then weighed.

The figures obtained are plotted in Fig. 4.

It will be observed that the alloy containing zinc shows most corrosion. This is in general agreement with work of previous experimenters. The plate was deeply and quite uniformly pitted. In the presence of the other metals the corrosion was very rapid, large depressions being formed round the screws. It was observed, however, that the corrosion round the steel screws was not nearly so marked as that around the brass and phosphor-bronze. This is what one would expect from our knowledge of the electrode potentials of the metals concerned.

Increased corrosion was observed in all plates when screws were present. In the case of the BS7 and N alloys the corrosion was not deep, the screws being held firmly in their places. Here also the steel screws stood up best. It is therefore desirable to avoid brass or bronze in the immediate neighbourhood of aluminium alloys in any structure exposed to corrosive influences. Iron and steel should be employed wherever possible, and even then a protective coating of paint or other material should be applied.

Except for the Z alloy, all the surfaces were remarkably smooth. No deep pitting was evident, the only exceptions being at a few isolated spots in the BS7 as cast. These were caused by some

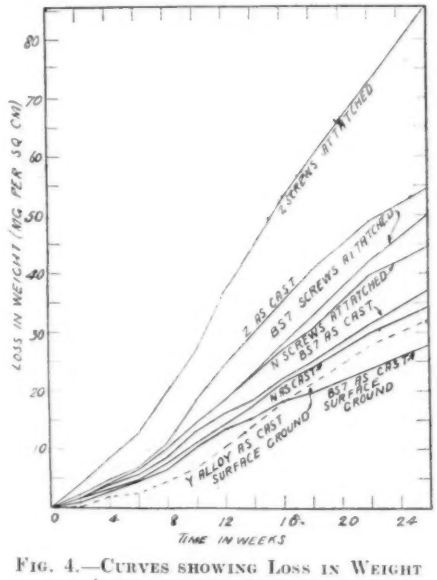

FIG. 4.—CURVES SHOWING LOSS IN WEIGHT OF ALLOYS UNDER SALT-WATER SPRAY CORROSION TESTS.

small holes originally present in the sand-cast sample. In their absence it is probable that this plate would have shown less corrosion.

The BS7 surface ground plate showed the best results. By taking into account all the results between BS7 and N a slight advantage is obtained by using the former. The "Y" alloy, although very promising in the first few months, corroded more rapidly at a later stage.

Except for the zinc alloy, the plates can be considered to have stood up well to the drastic conditions of corrosion. It is true that at present there are no aluminium alloys comparable with the stainless steels. Certain aluminium alloys, however, of restricted chemical composition can be readily employed under such conditions. By a protective coating of paint, so universally employed in the case of iron and steel, these alloys can remain unimpaired almost indefinitely. The rapid corrosion which aluminium alloys underwent when they were first introduced can be traced to the presence of zinc, which was generally employed for alloying purposes, and to the fact that the aluminium itself contained a large proportion of harmful impurities. This was particularly the case when sodium was present, an impurity remaining from the old chemical process of extracting the metal from its ores.

Heat-treatment Experiments.

All the experiments in this section were carried out on sand-cast bars. In no cases were chilled or wrought bars used. The test-bars were of the standard type previously described and cast in green-sand moulds.

They were heated in an electric furnace of the silica tube resistance type. The temperatures were taken by a platinum thermo-couple and indicator. This was previously calibrated by the usual cooling curve method.

The bars were maintained at a uniform temperature for six hours and then quenched in oil. Pre-

liminary experiments had shown this to be the best medium for quenching. The use of water was too drastic, causing low elongation. The bars were allowed to age for two days at room temperature before breaking.

The temperatures first employed were in the neighbourhood of 500 deg. C., this being the limiting temperature in use for alloys of the Duralumin type. Under these conditions only a very slight improvement was observed. By increasing the temperature to 540 deg. C. (the limiting figure for the "Y" alloy), no further improvement was effected. Better results, however, were obtained by increasing the temperature to about 600 deg. C. At this temperature alloys of the Duralumin and "Y" types would be rendered practically worthless. The structural changes taking place in these alloys would be accompanied by partial liquation, causing the material to be weak and brittle after the quenching operation. The fact that such a high temperature could be employed with beneficial results shows that the presence of iron and nickel must have a marked effect on the eutectic formation of the aluminium-copper equilibrium system. This eutectic melts at 540 deg. C., and must therefore be absent in alloys of the type under consideration.

It has already been established that the presence of a small percentage of nickel must have a pronounced effect on the aluminium-copper equilibrium system.* Experience with this and other alloys appears to confirm this view.

The results obtained by the heat-treatment of this alloy are included along with others in Table VI.

Effect of Magnesium.

At this stage it was considered advisable to try the effect of increasing the magnesium percentage. It has been generally established that magnesium plays an important part in the heat-treatment of aluminium alloys. Accordingly, a series of alloys with increasing percentages of this element were prepared. The compositions, together with the results obtained on the sand-cast test-bars, are given in Table V.

It will be observed that up to 0.7 per cent. magnesium there is a steady increase in breaking stress with a corresponding fall in ductility.

The bars were subjected to the heat-treatment processes already described. All experiments were carried out in duplicate, the figures obtained being mean values. They are given in Table VI.

TABLE V.—*Effect of Magnesium on Alloy BS7. Sand-Cast Test-Bar Results.*

Mark.	Composition. Per cent.						Mechanical properties.				
	Al.	Cu.	Ni.	Fe.	Mg.	Si.	Yield point. Tons per sq. in.	Breaking stress. Tons per sq. in.	Elongation. Per cent. on 2 in.	Hardness (Scleroscope).	Fracture.
BS7 ..	93.88	2.89	0.62	1.75	0.10	0.76	4.8	11.3	8.0	12	Crystalline.
BS14 ..	93.53	3.05	0.61	1.81	0.28	0.72	7.6	12.4	3.1	17	,,
BS11 ..	93.57	2.87	0.55	1.70	0.51	0.80	7.7	12.3	3.5	16	,,
BS15 ..	93.33	2.99	0.59	1.61	0.73	0.75	9.7	13.6	2.0	17	,,
BS13 ..	93.10	2.80	0.58	1.78	1.03	0.71	10.2	12.2	1.0	19	,,

By a consideration of these figures two important conclusions can be arrived at. Firstly, for each member of the series there is a certain temperature at which optimum results are obtained; secondly, as the percentage of magnesium increases this temperature falls. It is also noticed that in each alloy improved results are obtained until the optimum or critical temperature is arrived at. Beyond this temperature a marked deterioration takes place.

TABLE VI.—*Heat-Treatment Results on Sand-Cast Test-Bars.*
All Bars Heated for Six Hours at Temperatures Indicated and Quenched in Oil. Aged for Two Days at Atmospheric Temperature.

Alloy.	Magnesium. Per cent.	Temperature. Deg. C.	Yield point. Tons per sq. in.	Breaking stress. Tons per sq. in.	Elongation. Per cent. on 2 in.	Hardness (Scleroscope).	Fracture.
BS7	0.1	As cast	5.4	11.5	7.5	13	Crystalline, fine
		550	4.5	11.0	9.9	12	,, ,,
		600	5.4	11.4	5.8	13	,, ,,
		605	4.4	12.8	10.0	13	,, ,,
		615	8.4	10.1	4.8	13	,, ,,
BS14	0.3	As cast	7.6	12.4	3.1	17	Crystalline
		585	8.4	13.8	4.2	19	,,
		595	10.4	17.2	6.8	20	,,
		605	10.4	14.2	2.5	18	,,
BS11	0.5	As cast	7.9	12.5	3.8	17	,,
		400	4.6	10.4	5.6	13	,,
		560	4.6	9.9	5.0	13	Crystalline, fine
		570	9.8	16.2	5.3	15	,, ,,
		585	9.6	16.1	4.8	17	Crystalline
		595	10.5	17.6	7.5	19	,,
		605	6.4	9.2	2.5	16	Crystalline, coarse
BS15	0.7	As cast	8.4	13.3	1.8	16	Crystalline
		575	8.7	13.5	2.5	18	Crystalline, fine
		585	9.6	15.9	3.5	19	,, ,,
		595	10.8	11.0	0.5	20	Crystalline, coarse
BS13	1.0	As cast	10.2	12.2	1.0	19	Crystalline
		565	10.0	13.8	2.0	19	Crystalline, coarse
		575	9.2	13.4	2.5	20	,, ,,
		585	12.4	13.2	0.6	18	,, ,,

The graph showing variation of optimum temperature with the magnesium percentage is given in Fig. 5.

It is evident from these results that magnesium plays an active part in the constitutional changes undergone during heat-treatment. Recent work has traced this to the presence of magnesium silicide, and the important conclusions arrived at in the "Eleventh Report to the Alloys Research Committee of the Institution of Mechanical Engineers" appear to be confirmed by the results of these experiments. These conclusions were:—

The solubility of magnesium silicide at high temperatures was reduced by increasing the percentage (1) of magnesium, and/or (2) of copper.

The lower results at the optimum temperatures obtained by the higher percentages of magnesium

* "Eleventh Report to the Alloys Research Committee of the Institution of Mechanical Engineers, 1921."

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point to a reduced solubility of magnesium silicide. The larger the percentage of magnesium, the less the solubility of magnesium silicide becomes, with a corresponding fall in the tensile results. In the case of copper, the alloy fortunately experimented with at the National Physical Laboratory contained the same percentage as those in the series, namely, 3 per cent. These experiments showed that the presence of this amount of copper reduced the percentage solubility of the silicide from 1.6

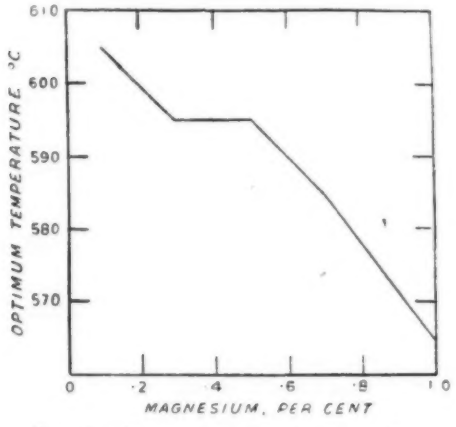


FIG. 5.—GRAPH SHOWING OPTIMUM TEMPERATURE WITH MAGNESIUM ADDITIONS.

per cent. to 0.9 per cent. This latter figure is equivalent to 0.55 per cent. of magnesium. The best results were obtained with the alloy approximating most closely to this percentage, namely, No. 11, indicating that maximum solubility had taken place.

The Properties of the Alloy BS11.

The results obtained from No. 11 lead to further investigation of this alloy. A series of remelting experiments similar to No. 7 was first carried out. The results are given in Table VII.

TABLE VII.—*Effect of Remelting Alloy BS11. Sand-Cast Test-Bar Results.*

	Yield point. Tons per sq. in.	Breaking stress. Tons per sq. in.	Elongation. Per cent. on 2 in.	Hardness (Scleroscope).
As cast..	7.7	12.3	3.5	16
1st remelt	7.9	12.5	3.8	17
2nd ,,	7.9	12.1	2.8	18
3rd ,,	6.8	12.7	3.9	16
4th ,,	7.3	11.3	2.5	16
5th ,,	5.6	11.5	3.5	16
6th ,,	6.6	11.9	3.7	15

Here again a first remelt shows a slight improvement, after which practically no deterioration occurs.

Attempts were then made to reduce the period of heating. Accordingly, two bars were heated for one hour at 595 deg. C. and oil-quenched, when the following results were obtained:—(1) Yield point, 9.6 tons per sq. in.; breaking stress, 17.4 tons per sq. in.; elongation, 6.4 per cent. on 2 in.; hardness (scleroscope), 20; (2) yield point, 10.4 tons per sq. in.; breaking stress, 16.0 tons per sq. in.; elongation, 3.8 per cent. on 2 in.; hardness (scleroscope), 20.

The improved figures resulting from this short treatment are comparable with the changes that occur in the heat-treatment of steels. Hitherto aluminium alloys have required prolonged periods of soaking to enable them to undergo those changes in structure requisite for improved mechanical properties. In many cases a refined structure due to chilling or working had to be adopted before these changes could take place within a reasonable time. The comparatively rapid change taking place in this alloy can be accounted for by the high temperature of heating that can be employed. At a temperature of 595 deg. C. considerably more mobility can be imparted to the structural components than at 500 deg. C. At the latter temperature structural changes in aluminium alloys are very sluggish, and unless the alloy can be heated to about 600 deg. C. rapid changes comparable with those of steel cannot be expected. At this temperature most aluminium alloys show signs of liquation, and therefore the necessity arises for so arranging the composition that these low melting-point constituents are absent.

Attempts were made to repeat these experiments on a commercial scale in a gas-fired furnace. Improved figures were obtained, but not to the same extent. This was ascribed to several causes, such as lack of uniformity of temperature in the furnace, greater difficulty in its control, and the presence of gases. In the case of metal for heat-treatment, it is even more desirable that it should be free from flaws and inclusions. The metal on being heated would be subjected to unequal expansion when such defects are present, with the formation of very fine fissures unseen by the naked eye, and so causing a deleterious effect on the tensile tests. In a number of cases lower results than those obtained from the preheated bar were caused by such defects. It is also possible that furnace gases penetrate these alloys. The latter, although apparently sound, are generally permeated by minute holes, visible only under the microscope.

The Physical Properties of the Copper-Cadmium Alloys Rich in Cadmium.

By C. H. M. JENKINS, B.Sc. (Teddington).

[SUMMARY.]

The mechanical properties have been investigated on alloys containing up to 5 per cent. of copper in the cast, rolled and annealed states.

The effect of even a small addition of copper to cadmium is to cause the formation of a second constituent $CuCd_3$; the presence of this constituent increases the tensile strength and Brinell hardness of the alloy and prevents the grain growth of cadmium on annealing.

The Brinell hardness number increases from approximately 25 to 50 by the addition of 4.8 per cent. by weight of copper for both cast and annealed alloys.

The tensile strength for cast material also rises from 5.4 to 9.8 tons per sq. in., with a corresponding fall in the elongation of from 52 to 0 per cent. for the addition of 4.8 per cent. of copper.

Annealed cadmium shows a tensile strength of 4.35 tons/sq. in., increasing to 9.05 tons/sq. in. by the addition of 2.90 per cent. of copper, the corresponding elongations falling from 57 to 24 per cent.

Additions of more than 3 per cent. of copper do not materially improve the mechanical properties of cadmium owing to the presence of too large a proportion of the brittle compound.

The Primitive Copper Industry of America.

By GEORGE BRINTON PHILLIPS, A.B. (Philadelphia, Pa.).

[SUMMARY.]

The account of the use of copper in pre-Columbian America as given by the old Spanish writers being considered "meagre and vague," the author has endeavoured to obtain more accurate information by an examination and analysis of the copper specimens found in museums. He advances evidence in this Paper of the existence of a prehistoric copper industry in America, carried on by aborigines, who—judging by the articles described and illustrated by the author—made widespread use of copper for tools, weapons, implements, ornaments and ceremonial objects. This extensive manufacture of copper implements of similar shape to take the place of the stone and bone articles formerly used—indicating a familiarity with the metal, and an appreciation of its advantages—would seem to justify the claim of a primitive copper culture for the American Indians, suddenly interrupted by the arrival of the Spaniards and the knowledge of the greater advantages of the use of iron and the terribly destructive weapons made of that metal.

The Influence of the Time Factor on Tensile Tests Conducted at Elevated Temperatures.

By JOHN S. BROWN, M.B.E., A.R.T.C. (Glasgow).

[ABRIDGED.]

The service required from the materials used in the engineering industry frequently involves the part being subjected to conditions of temperature which cause the strength to vary from the value shown by the simple, cold, tensile test as used for classification purposes; and while our technical literature includes many records of investigations on the strength of materials at elevated temperatures, there is also a general experience that these results require to be applied with considerable caution in practical service. As the margin provided by the usual factor of safety is relatively large, this position involves a distinct reflection on the testing procedure used in the laboratory, and there would appear to be a call for further assurance that the laboratory procedure legitimately represents the conditions which hold during service. With this object a survey of testing methods has been made, and shows the only departure between laboratory and practical conditions to be in the restricted time in which the laboratory tests are commonly carried through; thus any progressive weakening of the materials which might occur while under load would not be given an opportunity to make itself evident. And while the rate of application of the load as adopted in tests of the commercial type is known to lead to a result which is only slightly high, it appears to have been accepted that a similar condition would hold throughout the complete range of temperatures. This position has probably arisen from the inconvenience which is associated with the manual counterpoise control on the standard type of testing machine, making continuous attention necessary throughout the period of a test: and it was due to a novel machine being available that it became attractive to proceed with the experimental work about to be described.

The experimental records trace the influence of both short and long test periods on the ultimate strength of a range of materials, and do not touch on the feature described as "creep" in the work of Dickenson and others on steels.[1] The publication of Dickenson's Paper in 1922 drew attention to this phenomena, but the present investigation was then sufficiently advanced to make it appear inadvisable to deflect from the basic form of the tests. It has been found that the procedure previously considered acceptable largely neglects a time factor which has an influence of sufficient prominence to explain the whole of the discrepancy found in the practical use of these materials.

The introduction of a term involving time gives the tensile test a form in which three independent factors have to be observed—*i.e.* time, load, and temperature. In carrying through the test any two of these may be controlled, leaving the third as the variable; and, correspondingly, the procedure may follow any one of three fundamentally different forms. These are as follows:—

(*a*) The rapid raising of the temperature of the specimen to a selected value, which is stabilised (over, say, half an hour), and then applying an increasing load to give rupture within a matter of minutes. The ordinary commercial test is a special case of this type. This has also been the chief basis of previous work at elevated temperatures, and it is interesting to note that the time factor has generally been neglected to a degree which makes it quite the exception for any reference to be made to either the duration of the stabilising period or the rate of application of the load. But it is understood that each has been completed in a matter of minutes, as indicated.

(*b*) The application of a selected load and then heating under conditions which give a uniform rate of increase in the temperature (of several degrees per minute) until rupture takes place. The adoption of this procedure is not common; but it formed the basis of Ingall's extensive investigation.[2]

(*c*) The application of selected values of the load and the temperature, followed by the observation of the time interval which elapses until rupture. The work of Dickenson, just referred to, was made on this basis; but there the stress was so low that the tests continued over a period of a year without rupture taking place; while a daily record was kept of the elongation.

The normal conditions of service of engineering materials involves the concurrent application of the load and the temperature, and if the various procedures just outlined do not lead to completely concordant results, there can be little question that only type (*c*) has any legitimate connection with practice. In this investigation it has been confirmed that such a discrepancy does exist. Thus the procedures outlined under (*a*) and (*b*), as commonly applied, fail to bring out the true characteristics of the materials, the strengths which they show being quite artificial, and, since they are high, they are due to be regarded as dangerously misguiding.

For these reasons attention becomes directed to the procedure given under (*c*). Here the conditions would only appear to become completely representative when an extensive period elapses before fracture; and it can be conceived that a choice of stress and temperature values which approached those under which the material gives satisfactory service would lead to the plant being set aside for a time which might extend over many years. A strict adherence to this procedure could only be followed under conditions which made available both a battery of testing machines and an observer with quite unusual patience. But by developing a scheme of systematic variations from strict adherence to the procedure, it has been found possible to throw sufficient light on the stress-temperature-time relationship for a modified form of test to be developed which places a fairly definite restriction on the time the machine is likely to be occupied by a single specimen: and this without involving any material sacrifice in the accuracy of the result. In this form the test reverts towards type (*a*), but with the important restriction that the rate of application of the load is to be less than 1 ton per sq. in. per day. The original development of this testing procedure arose during work prior to that now being considered, but as each new material was brought under test a point has been made of checking that the characteristics continued to justify this form of procedure. It would have been quite impossible to carry the work to any very effective stage, with the one machine available, had this intermediate type of test not come to light: and its review is not the least important portion of this paper.

Testing Plant.

The new testing machine is shown in Fig. 1, and is built from triangular platforms of cast iron on 1½ in. dia. steel columns. The centre platform is guided on the columns, and is raised or lowered by the screw which passes through the hand-wheel boss. The large spring rests on this platform and has its upper end connected through to the specimen. The deflection of this calibrated spring forms a measure of the applied load, and is varied by raising the centre platform by the hand-wheel. Axial application of the load is ensured by the adoption of a screwed specimen in conjunction with the opposite end of the grips being centred on steel balls. When the specimen fractures the spring is freed, and the strain energy is taken up by the use of wood-packing at the upper end to restrict the free movement to a minimum. The grips are guided by side stops to prevent damage to the furnace tube at this time. A clock recorder gives a record of the time interval which elapses before failure occurs, the test being continuous, day and night, from commencement. With a specimen of 0.05 sq. in. cross-section the maximum stress obtainable is 22 tons per sq. in., and under this condition the spring deflection is 0.25 in. per ton per sq. in., which allows fractional readings to be readily taken. This range of stress is well suited for the temperature conditions which are being considered, but where a stress in excess of this value is likely to be

1 For a general review see Mellanby and Kerr, *Trans. N.E. Coast Inst. Eng. Ship.*, 1925, and following discussion.

2 *J. Inst. Metals*, 1924, 32, 41.

involved the cross-section of the specimen is reduced.

In the previous work on the strength of materials at elevated temperatures it has been established that the required heat conditions can best be obtained by surrounding the specimen, together with the adjoining ends of the screwed grips, in an electric furnace; while the local temperature of the specimen in this shrouded position is conveniently obtained by the adoption of the thermo-couple pyrometer. These methods have been used throughout the present work and call for little explanation. The thermo-junction of copper-Constantan was tied to the specimen by a strand of asbestos, which was so arranged that it acted as a shield from the furnace wall radiation for both the junction of the wires and the points at which these left the specimen. The e.m.f. was read by the Null method, and the temperature was then obtained from a previous calibration of the wires. The electric furnace consisted of a silica glass tube 1.75 in. diameter by 10 in. long wound with Nichrome resistance wire and heat insulated by asbestos and magnesia.

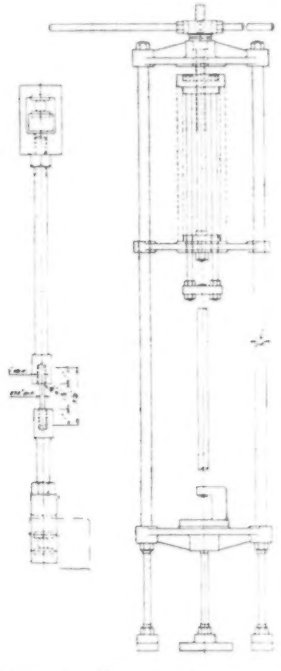


FIG. 1.—TESTING APPARATUS USED.

Current was taken from the town mains, the temperature regulation being obtained by an external resistance consisting of banks of lamps under switch control.

Test Procedure.

The evolution of the plant which has just been described was based on the requirement that the specimen was to be subjected to selected service of stress and temperature for a period that could be extended indefinitely; the primary object being to learn the time interval that would elapse before failure, as given by the clock recorder. Where failure did not take place within an arbitrary limit of time, which was varied during the progressive development of the tests, the conditions could then be altered to a slightly more severe form and the period of observation commenced anew—that is to say, the increase in load has been made in small steps and not as a continuous rate. In this way the conditions which finally gave rupture have been gradually approached; and immediately preceding the state which caused failure there is a slightly less severe condition which the material withstood for a prolonged period. The latter condition represents a limiting value of the working stress, where the period of useful life is similar to the corresponding period of observation, and is known to a degree of accuracy which only involves the size of the stress increment with which the final conditions were approached.

The results obtained in this manner still fall short of practical service in the restriction of the time element, but they are of immediate value for comparison with tests in which the time of test is still further reduced; and it is only when the variation in time has no influence on the result that the test results have an immediate practical application. It is from a further analysis of such results that features are shown which suggest conditions under which the tests in the machine just described appear to become representative of the continuous service available from the materials.

The results given by each of the materials tested are presented as graphs in Figs. 2 to 5, the co-ordinates being temperature and tensile load. The third factor, time, is dealt with by marking it against each point, the figures being the hours during which the particular combination of stress and temperature were maintained; where no such entry appears a period of 24 hours is to be understood, the omission having been made to avoid further confusion of the diagram. The final failure of the specimen is indicated by a circular point lying at the end of a line which connects the progressive stages through which the failure was approached: in this way the whole course of treatment of each specimen has been indicated. The full line curve passing among the points generalises the results into a strength-temperature characteristic. Little attention has been given to the conditions around atmospheric temperature: the cold strength, used for the beginning of the curve, is from a rapid loading test. In general the daily, or other, progressive changes were in the load, although instances occurred where the limit of capacity of the machine was reached and increments in temperature had then to be accepted. These are indicated by the diagrams.

The diagrams also record the results given by a series of tests of the half-hour type (procedure (*a*)), in which the temperature was maintained uniform over this period, and the load then rapidly increased, from zero, to give fracture; these are indicated by points (X), and are connected by a dotted curve.

The testing programme included certain variations in the procedure, made with the object of establishing the effect of two secondary factors which might have sufficient influence to diminish the value of the results. The first point relates to the restriction of each stage in the test to 24 hours, and it will be appreciated that any lengthening of this period may well add to the conclusive value of the result, but is attained at the expense of additional time being required to complete the work. The diagrams include a number of cases where this time has been extended, and it will be shown that nothing of further interest has been brought out by continuing the test for any reasonable period beyond the figure of 24 hours. It is to be understood that this conclusion can only apply to the materials so far investigated. Secondly, there is the experience that the weakening effect arises from the associated conditions of stress and temperature, and makes its appearance in quite a critical manner. Thus a series of preliminary periods, under conditions which are progressively more severe, will show the same final value for the strength as that of another specimen for which the preliminary periods were largely omitted by a judicious selection of the initial conditions. On this basis it becomes unnecessary to commence each test at zero load and work up to the breaking strength in increments of 1 ton per sq. in. per day; it being sufficient if the conditions can be so chosen that the life extends over one period of a day.

Tests on High Tensile Brass.

The material (Fig. 2) was provided as machine-screwed bars, ½ in. Whit., and was then reduced in diameter in the centre of each length to give the required form of specimen.

The half-hour tests require no comment at this stage, as they follow closely on the work of the earlier investigations.

The long-duration tests were commenced around 370 deg. C., where the half-hour strength had been over 17 tons per sq. in., and successive specimens, under loads of 10 tons, 7.5 tons, and 4 tons per sq. in., each gave failure in 2 hours.

These results give an immediate illustration of the fundamental change in the characteristics under the new procedure; and, as the final condition indicated that no useful service could be obtained from the material when at this temperature, the matter was not carried to a definite conclusion by the use of further specimens at still lower stress values. The uniform life of 2 hours shown under the successively reduced loads is somewhat remarkable; but no explanation is here being offered. The failures at 204 deg. C. and 260 deg. C. occurred at periods in excess of 24 hours, and show that the weakening of the material is not entirely completed within that time. At 150 deg. C. two specimens were expended; the first was of the normal cross-section, and proved to be beyond the capacity of the machine, although heated under increasing loads over a period of 120 hours; it was disposed of by increasing the temperature, and the close relationship between the strength then shown and that of the half-hour curve forms the point of a later remark. The second specimen at 150 deg. C. was of reduced cross-section, and after 96 hours at a relatively high load it was broken while changing the conditions.

The curve through these test-points is not particularly well established at the higher tempera-

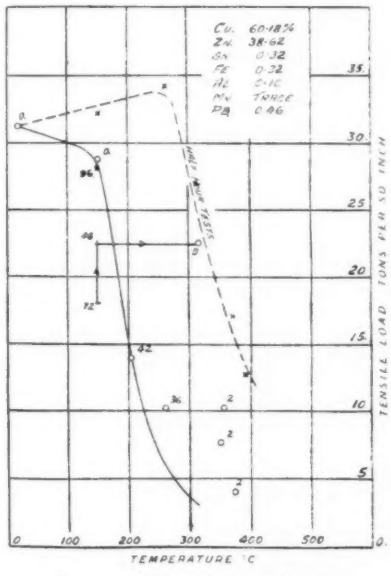


FIG. 2.—HIGH TENSILE BRASS.

tures, but the strength is then so low that the material can have no practical interest. Comparison with the half-hour series shows that the longer period of heating has disposed the change point from 260 to 150 deg. C., a matter of 110 deg. C., and it would consequently appear to be inadvisable to attach importance to matters which arise out of change-points derived from tensile tests. On passing above atmospheric temperature the two curves take opposite directions, that from the half-hour tests showing a rising strength, while the long-duration tests show a diminishing strength; the former, the rising strength characteristic, has previously been shown for several materials, but is probably somewhat redundant, and it is interesting to find that it disappears under the new procedure.

Phosphor Bronze.

The very general use of rolled brass bar in steam fittings makes it of special interest to consider the bearing of the present results on engineering practice. Thus at the higher steam pressures there is a very general experience that a stop-valve spindle requires much care in handling if seizure in the bridge is to be avoided. For saturated steam at 235 lbs. per sq. in. the temperature is about 200 deg. C., and reference to the curve shows that the brass has then only half its original strength; indeed, the material is no better in respect of the strength than a good cast iron Probably it is fortunate that these spindles commonly operate in compression.

This material (Fig. 3) was available as a turbine-blading section of heavy proportions, as used for forming the unit type of blade and packing.

The cold tests with rapid loading gave a strength of 27 tons per sq. in., and were followed by a test of the same type at 440 deg. C., where the strength shown was 21 tons per sq. in.

In the light of the latter result the first of the long-duration tests was commenced at the same temperature, but with only half that load; it resulted in failure at the end of two hours. For the following specimen the same load was applied, but the temperature was restricted to 300 deg. C.; this lengthened the life to twelve hours. From the information available at this point it became possible to sketch an approximation to the graph, and the conditions imposed on each following specimen were selected in the light of this guidance. The specimen which commenced under 225 deg. C. had a very extended period of heating, and its falling in with the other results is taken to indicate that it is only in the final phase of the test that weakening commences in the material. In two cases, following on an initial period under observation, the stress was rapidly increased to give rupture, and in each instance the strength shown is considerably above that given by a strict adherence to the procedure otherwise followed.

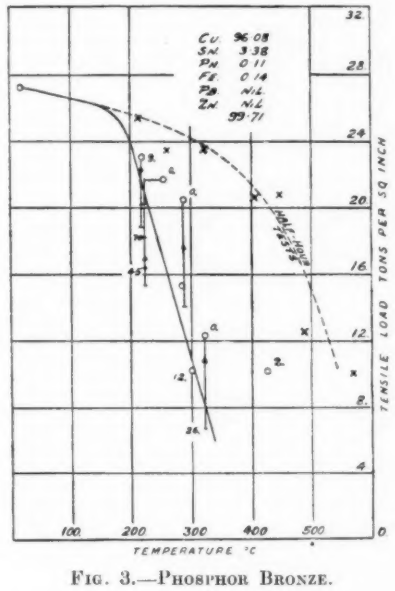


FIG. 3.—PHOSPHOR BRONZE.

This feature is referred to in the concluding remarks.

The tests of the half-hour type (X) extend somewhat beyond the range of temperatures found of interest in the long-duration series, but the only effect has been to make the difference in the characteristics more prominent. Here the point of departure between the curves lies at 180 deg. C., and the strength falls to half the original value, about 280 deg. C. Under the conditions of centrifugal loading which arise in turbine blades the use of large cross-sectional areas does not give a direct reduction in the working stress, and the present sample of material is consequently quite unsuitable for service under anything beyond a moderate superheat.

Monel Metal.

The specimen (Fig. 4) for the tests on Monel metal were prepared from a rolled (or drawn) bar of 0.5 in. diameter and were screwed and turned to size as for the earlier materials; due to the higher strength, an increased proportion of the specimens were of 0.20 in. diameter.

The tests of the half-hour type are only sufficient in number to give the outline of the characteristics associated with these conditions, but it is of interest to notice that they follow those on record for the material, and may be taken to indicate that the composition of the sample was quite representative.

Comparison of the tests of long and short dura-

tion again confirms that the time factor exercises a prominent influence on the strength. The point at which the curves depart from each other lies at about 350 deg. C., and at 410 deg. C. the strength is below half that given at normal temperature.

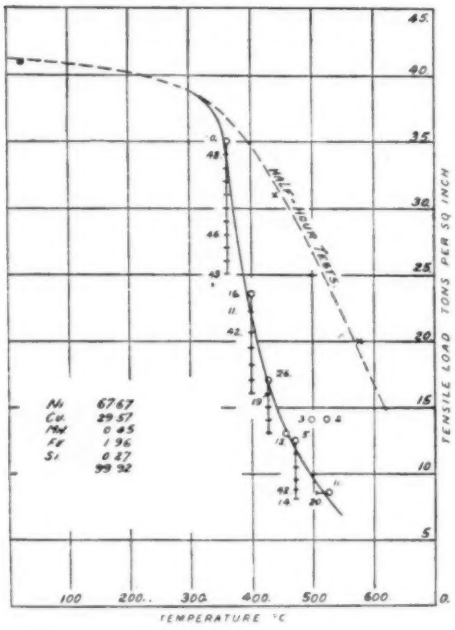


FIG. 4.—MONEL METAL.

Cast Aluminium.

The section of this material provided six specimens (Fig. 5), and had been cut from a piston of a large internal-combustion engine.

The cold-strength with rapid loading was 10.7 tons per sq. in., while a test of the same type at 371 deg. C. showed 6.7 tons per sq. in.

From the latter result the long-duration tests were commenced at 370 deg. C. and 3.4 tons per

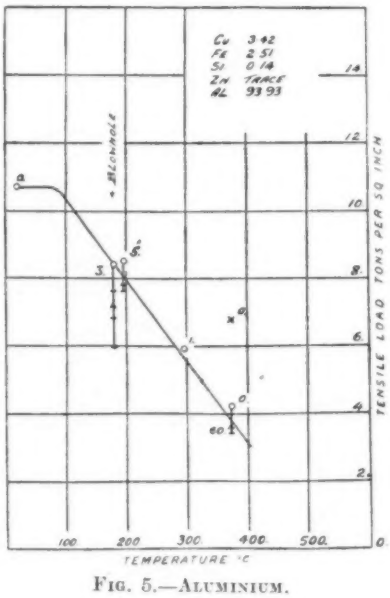


FIG. 5.—ALUMINIUM.

sq. in., and to study the influence of the rate of loading, this condition was maintained for 60 hours; but failure did not take place. Then, on attempting to increase the loading, failure occurred at 4.2 tons per sq. in. The remaining specimens were then dealt with as indicated in the graph. That tested at 177 deg. C. shows a lengthy period under increasing loads, and in falling in with the other results it is taken to support the view that the material remained in an unweakened condition until a critical point closely adjacent to the final strength had been passed.

Here the single half-hour test at 370 deg. C. is alone available for bringing out the difference between the testing procedures, but clearly it has no connection with the long-duration tests. Many curves showing the half-hour type characteristics for different aluminium alloys are available, and the change-point is found to vary little from 250 deg. C. For the particular type of rapid loading adopted by Ingall this temperature became 150 deg. C. for pure aluminium. The present investigation places this change-point at 100 deg. C. This displacement to a lower temperature has already been demonstrated in the tests on other materials. In the Light Alloy Research report it is noted that for aluminium there is a reduction of strength as the time of loading is extended, but the range of times investigated was very restricted, and the important bearing on the practical value of the material does not appear to have been fully appreciated.

CONCLUSIONS.

In each diagram the series of results given by the long-duration tests have been connected by a full line curve, so located as to bring out the variation in the useful strength of the material over a range of temperatures which covers all conditions under which any reasonable proportion of the original qualities are retained. Some points lie above these curves, but examination will show that each instance is associated with a very restricted life, and thus provides evidence which prevents the curve being displaced in an upward direction. On the other hand, it is a much more open question as to whether a considerable prolongation of each stage in the test might not have provided results which would bring the curve to a slightly lower position, but the general characteristic shown by such tests as were of extended duration either shows that failure does not occur, or that the strength then found is in agreement with corresponding tests covering only a 12-hour period, and both circumstances support a view that the progressive weakening of the material is completed within the period of 24 hours, as normally adopted in the scheme of testing.

Comparison of the half-hour characteristic with that from the tests of longer duration shows there is a restricted position of the lower temperature range over which the result is independent of the procedure adopted, but beyond a certain critical temperature the curves depart widely from each other, the long-duration tests showing a relatively rapid reduction in strength. As the long-duration tests merely approximate more closely to actual service conditions, the practical value of all the records from tests of the half-hour type on various materials have evidently been brought under suspicion, and the critical temperature feature would appear to leave no scope for the derivation of a correlating factor to connect the different procedures. In these circumstances the work which has been described merely forms an introduction to an extensive field of investigation.

Three of the materials which have been handled are noted for their ductility when tested at normal temperatures, but the long-duration tests were found to be associated with a diminution in both the elongation and reduction in area, the latter at the higher temperatures being practically nil. It is not proposed to submit details of these characteristics, as they are not only somewhat incomplete and complicated by two diameters of specimen having been used, but also the form which the work has taken makes it desirable to confine attention to the strength of the material alone.

Considerable attention has been given to the question of finding some procedure which would reduce the time required to carry through a test, while still ensuring that the prominent time effect does not vitiate the result. There appears to be little scope for improvement in this direction. Thus the adoption of a stress increment in excess of 1 ton per sq. in. would enable the final condition to be more rapidly approached, but the ratio of this increment to the final strength is an important factor in the accuracy with which the result is given, and it is consequently unattractive

to consider any material departure towards a larger increment than the value just quoted. Alternatively, it appears unnecessary to consider a smaller value for this increment in view of the variation commonly found between a series of similar specimens tested under identical conditions. During the investigation the opportunity has been taken of making variations in the procedure to provide further light on this matter, and has brought out the critical manner in which the final phase makes its appearance; it thus becomes of no service to accelerate the final stages of the test in an expectancy that a lengthy preliminary heating at the lower stresses or temperatures will have caused a modification in the characteristics of the material; such is not the case, and the final strength may show little change from that which would have been obtained by a test of the half-hour type. Several examples of this effect are provided in the figures; thus for brass, five days under load at 150 deg. C. did not alter the strength for rapid loading at 315 deg. C.; while for phosphor-bronze at 290 deg. C. a specimen withstood 14 tons per sq. in. for 24 hours, and on rapid loading fractured at 20.5 tons per sq. in., but the succeeding test showed that 17.5 tons per sq. in. could not be carried indefinitely.

The present basis of testing is unlikely to be considered suitable for the routine classification of materials under the conditions found in an engineering works; although a type of proof test might be developed where certain requirements of temperature and stress, each carrying a margin over the subsequent conditions of service, would be imposed over a period of a reasonable duration.

This investigation has been carried through in the Engineering Laboratory at the Royal Technical College, Glasgow, and special acknowledgment is made of the encouragement received throughout its development from Professor A. L. Mellanby, D.Sc. As it fell beyond the scope of ordinary duties there has been an unusually heavy call on various forms of assistance, and it is only the keen interest with which this has been given that has brought the work to the present stage. Thanks have also to be expressed to Mr. J. W. Donaldson, B.Sc., metallurgist with Messrs. Scotts' Shipbuilding and Engineering Company, Limited, Greenock, for the analyses, which made the diagrams a complete record of the tests.

On the Constitution of Zinc-Copper Alloys Containing 45 to 65 per cent. of Copper.

By MARIE L. V. GAYLER, D.Sc.

[SUMMARY.]

An equilibrium diagram of zinc-copper alloys containing 45 to 65 per cent. copper is submitted, based on the microscopic examination of well-annealed alloys. The phase field boundaries, for reasons stated, are drawn showing a slight but definite change in direction at the temperature of the β transformation point. No change in microstructure of alloys consisting wholly of the β constituent could be detected. The temperature of the transformation is not given as a horizontal in the constitutional diagram, since thermal curves show that the temperature is higher on the γ than on the α side of the β field.

The Constitution of Alloys of Aluminium, Copper and Zinc.

By D. HANSON, D.Sc., and MARIE L. V. GAYLER, D.Sc. (Teddington).

[SUMMARY.]

A full description of a research undertaken to confirm or disprove the existence of certain invariant points as found by Jares; to find the correct interpretation of the invariant reaction corresponding to the θ point of Jares and the ternary eutectic of Haughton and Bingham; to determine the constitutional changes which take place below the solidus in alloys containing up to 25 per cent. copper.

The Influence of Pouring Temperature and Mould Temperature on the Properties of a Lead-Base Anti-Friction Alloy.

By PROFESSOR O. W. ELLIS, M.Sc. (Toronto, Ont., Canada).

[SUMMARY.]

The Paper presents the results of work carried out during the past three years in the laboratories of the Department of Metallurgical Engineering of the University of Toronto. The results of these investigations may be summarised in the following terms:—

(1) Within the limits of the experiments recorded the replacement of lead by antimony increases the resistance of these alloys to compression. The hardness of these alloys is subject to a like increase.

(2) Within the limits of these experiments the replacement of tin by copper increases the resistance of these alloys to compression. The hardness, however, is scarcely affected by the substitution.

(3) Mould temperatures exert a more powerful effect on the alloys referred to in the Paper than do pouring temperatures.

(4) For a given temperature of mould increase in pouring temperature results in an increase in the size of the γ-cubes and in a coarsening of the matrix of the copper-free alloy.

(5) Increase in pouring temperature has less effect on segregation than increase in mould temperature.

(6) Increase in mould temperature causes a reduction in the resistance of these alloys to slowly-applied stresses. The copper-bearing alloy has not been fully investigated in this respect.

(7) Addition of copper has an important effect on the structure of these alloys.

(8) There is evidence for the belief that an intermetallic reaction occurs in the copper-bearing alloy investigated by the author in the liquid state at 334 deg. C.

Passification and Scale Resistance in Relation to the Corrosion of Aluminium Alloys.

By L. H. CALLENDER, B.Sc.

[SUMMARY.]

The Paper covers an investigation of the conditions which govern the corrosion of aluminium alloys with a view to promoting the applications of these materials in industry.

Aluminium is a passive metal. Its normal reactions are modified by the presence of a hydroxide scale of high mechanical, chemical and electrical resistance. Corrosion of the metal in water may be started by solution of peptisation of this scale; it may be stopped by precipitation of scale on the metal surface. Scale may be formed by electrolytic action, the anodic product in water being aluminium hydroxide which tends to adhere to the metal and passify it. Some experimental results are given in the paper showing the action of oxidising salts in passifying the metal and protecting it from corrosion.

An electro-chemical method of experiment is applied to the investigation of the rate of formation of resistant scales on aluminium alloys in different salt solutions. The metal is made the anode in the salt solution and the rate of increase of the cell resistance is measured; at the same time, the adherence of the scales formed are tested by brushing and their rate of reformation studied.

These experiments tend to show that the action of chlorides is to reduce the resistance and adherence of these scales, and that carbonates tend to increase scale resistance. Nitrates passify the metal by direct oxidation and anodic polarisation. The action of bichromates is particularly interesting, for they combine the passifying action of nitrates with the formation of a highly resistant scale containing chromate.

It would appear that this electro-chemical method of experiment might be usefully applied to the investigation of factors influencing the corrosion of other metals and alloys besides aluminium.

XUM

Castings which Give Trouble Under Pressure Test.

By S. G. Smith.

STEAM TURBINE CYLINDERS.

Turbine cylinders of the Rateau-Impulse type are made in cast iron of special quality. There may be exceptions with certain parts that are attached to the cylinder that may be cast in steel, but these exceptions only apply to the very large turbines capable of developing up to 30,000 h.p. With these powerful machines the complete cylinder may be constructed in several parts, but the bore, *i.e.*, the diameter, which receives the various conditions both for marine and land power. The type shown in Fig. 1 has the side frames for the bottom half of the cylinder cast separate and bolted up to the cylinder.

The design for a less powerful machine incorporates the side frames and bottom half of cylinder being cast in one piece, as shown in Fig. 2, thus obviating the usual separate turbine bedplate or side frames. The section outline of an older type of a still lesser powerful machine

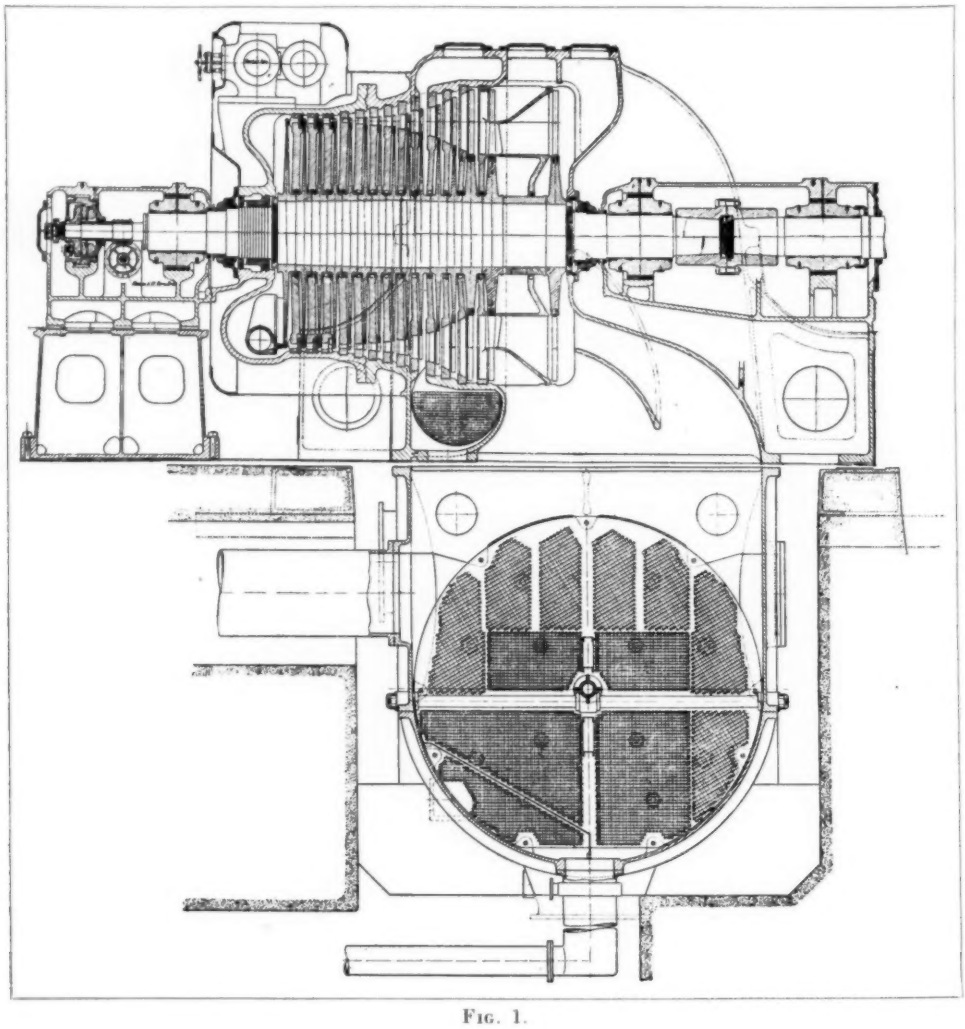


FIG. 1.

stationary bladed diaphragms, very rarely exceeds two pieces in the top half and two pieces in the bottom half of the cylinder. The weight of some of these pieces approaches 30 tons.

To give uninformed readers some idea of these monster engines, it may be stated in passing that the bore for the diaphragms is about 9 ft. The total weight of pieces composing the cylinder and frame would be nearly 100 tons. The condensers are 11 ft. dia. by 18 ft. long. Including the water box and covers, the weight would exceed 60 tons. The generator casting is nearly 30 tons; by including the steam chest, diaphragms, etc., the approximate weight of castings alone would exceed 250 tons. As a matter of interest, Figs. 1 and 1A show a sectional outline of one of these engines, built by the Metropolitan Vickers Company for the Dalmarnock (Glasgow) Power Station.

There are numerous designs of steam turbines of the Rateau type that are made suitable for is shown in Fig. 3. The remaining illustrations confine themselves to sections of the parts where trouble has in the past been experienced under testing pressure. The whole of the cylinders and frames of turbines are subjected to pressure tests. The bore and exhaust have to withstand 30 lbs. per sq. in., whilst the steam belt and adjoining walls have to be proof against a pressure of 400 to 500 lbs. per sq. in. These pressures are applied before assembling is commenced.

The bore section of the cylinders vary considerably. Unfortunately in the past the thickness was often such that it was required to cover more than one given diameter, *i.e.*, the finished bore was subject to modifications, consequently when a small diameter was required, the bore section was much thicker than was necessary. That alone mitigated very much against the density of the iron, and also increased the possibility of porosity.

It is now realised by the engineers from a foundry view-point that such is totally wrong, and are in agreement that whenever possible the the cylinder that require constant care in order to prevent leaking under pressure, not only from porosity brought about by thick sections and

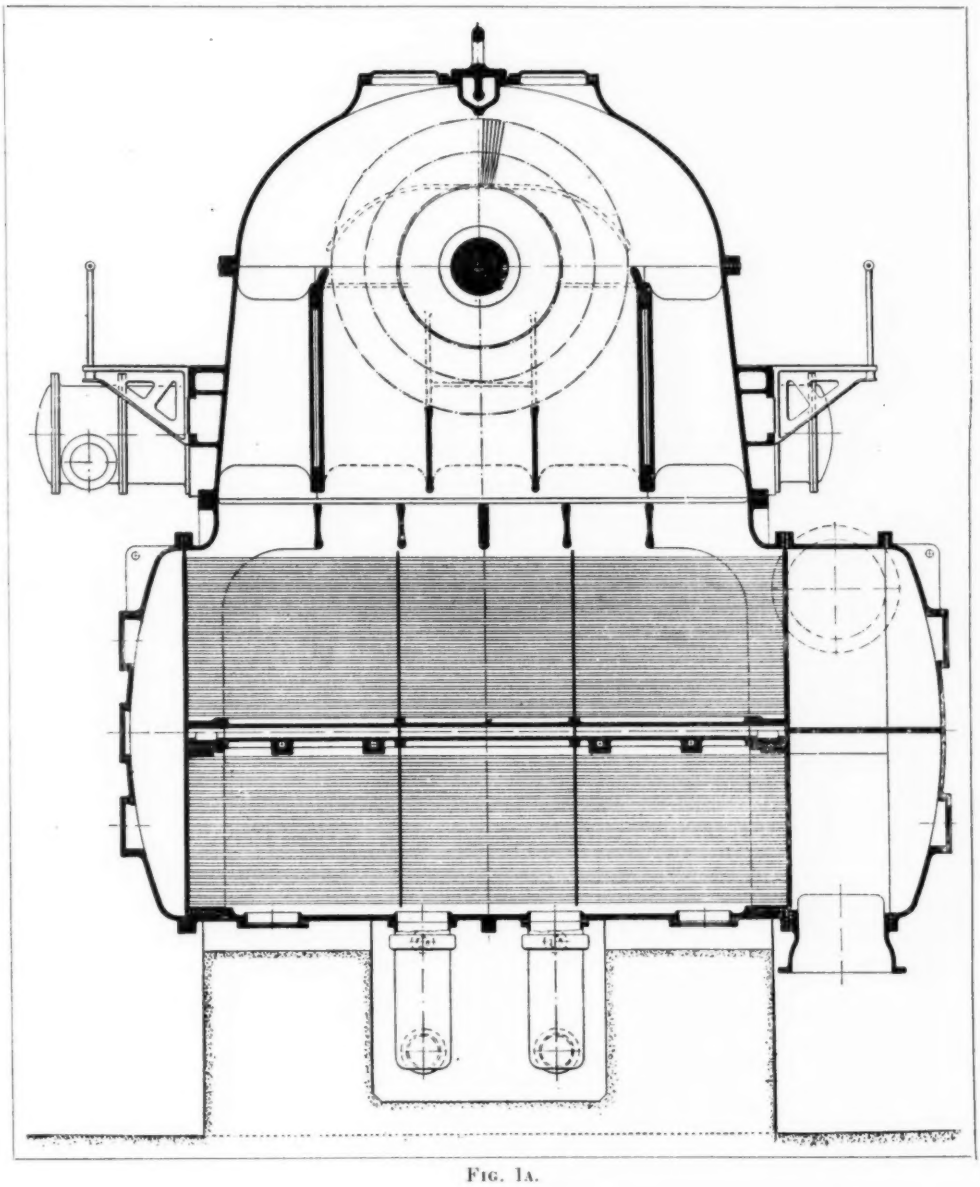


FIG. 1A.

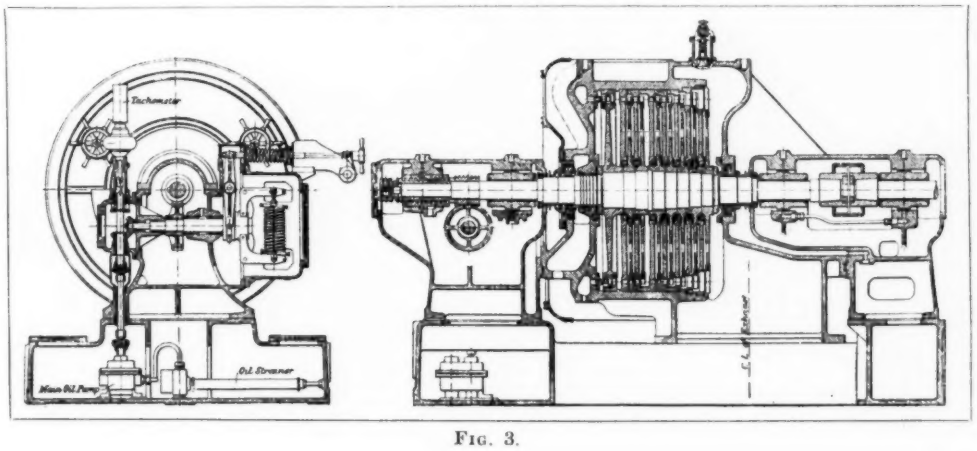


FIG. 3.

variations of the bore section should be within reasonable limits, with a minimum of machining covered, of course, by a margin of safety. Even when this has been done there are still places in slow cooling, but also from accumulated dross, dirt, and dust during pouring, chiefly due to erosion of the mould and cores, also possibly the boiling of the metal from hard, damp, or

insufficiently vented places of either mould or cores. This, of course, results in scabbing, and all such matter must float on top of the metal or otherwise be trapped, and if some provision is not made for it to find an exit, it remains in some part of the casting to be discovered during machining, or, when under pressure, test.

Four Points to be Observed.

During the experience of the writer, covering some hundreds of turbine cylinders of various dimensions, from a 12-in. bore to a 9-ft. bore, the moulding, core-making, pouring and feeding of which have received special attention, due to a variety of defects, it was found that the following precautions were advisable: (1) A turbine cylinder, whether large or small, should not be poured slowly, neither should it be poured with dull metal. Of the two evils, the lesser risk would be when pouring slowly with a very high temperature iron; (2) If there exists a heavy section liable to either porosity or drawn places, means must be found to feed such places or adopt other measures to ensure soundness; (3) no chaplets or studs (unless definitely necessary) should be used in the bore or steam-way belt; and (4) the mould and cores should be thoroughly dry and the venting always ample.

These precautions do not exhaust all that may be enumerated.

Fig. 4 shows a section of a bottom half cylinder which has at different times been made in both loam and sand. It is moulded and poured similarly to the way shown. The half-cylinder and bearings (not shown) are made in one piece, the weight being about 10 tons. The bore section (B.S.) is very thick, and unless some provision is made for feeding the bore at the top, would, when machined, be porous and drawn. The methods adopted are shown in the sketches. The area of the feeder (A), which is 8 in. by 10 in., passes through the section of the exhaust to the heavy part of the bore. When feeding, the rod, to be effective, must reach within an inch or two of the bore core.

Fig. 5 is the top half of the cylinder shown in Fig. 4, and of similar bore. The area of the feeding head was finally standardised at 8½ in. by 7½ in., and was fixed in the position shown (B). The small feeder at the end (C) also needs to be fed with a feeding rod.

Fig. 6 is a section of a much smaller bottom half-cylinder, and as in Figs. 4 and 5, the feeder passes through and encloses part of the exhaust section. The area of the feeder is 6 in. by 8 in.

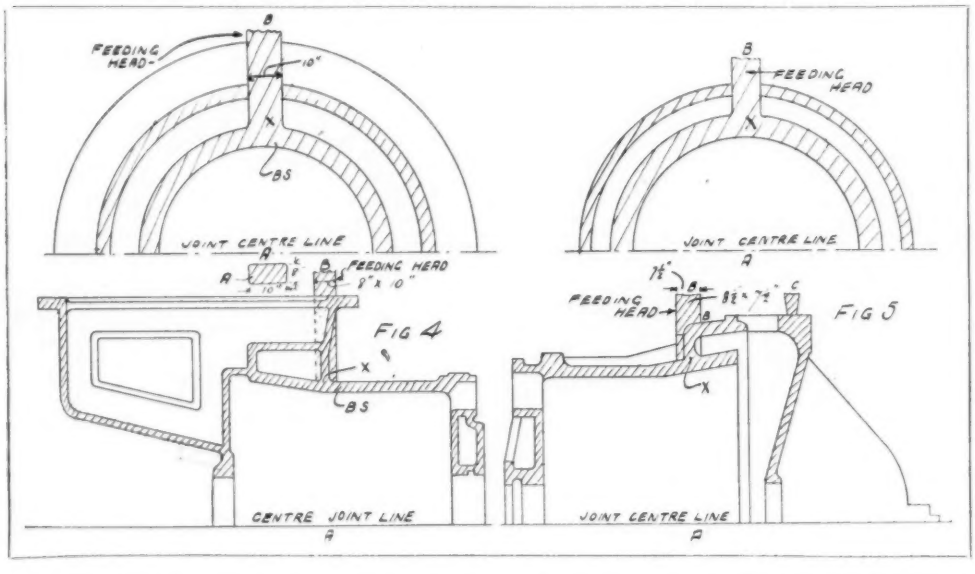


Fig. 7 is a section of a top half-cylinder of a different design; the area of the feeder is the same as in Fig. 6. The position which encloses the lifting eye-bolt boss is shown at A, whilst B shows the other lifting eye-bolt boss with a small feeder.

Castings of the type illustrated in Figs. 6 and 7 have on occasion given much trouble under pressure test by leaking occurring in the area now covered by the feeder. These large-area feeders serve a double purpose. It is not necessary to have feeders of these dimensions to feed only the casting, but from experience it can be stated that it is necessary to employ risers of such a size for the accumulation of dross and dirt to find a way of escape from the actual casting. This locality being near the highest part of the casting, it serves its purpose admirably. The writer has on several occasions watched this feeding riser flow up when pouring, and it is amazing the quantity of accumulated dross that is formed in the centre of the riser, lumps of dross as large as one's closed fist being quite common. If this detritus did not pre-

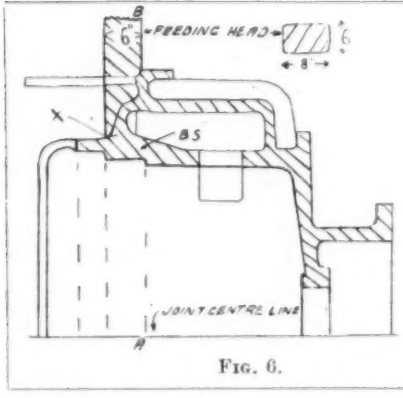


FIG. 6.

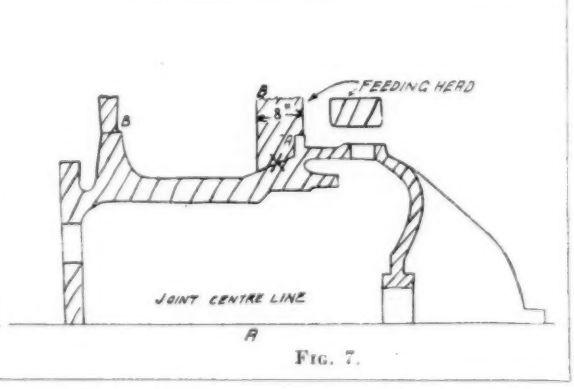


FIG. 7.

viously escape, it would be left in the casting to give endless trouble and finally be the cause of rejecting the casting.

In all cases the most important part that requires to be fed "sound" is the root of the feeder, *i.e.*, the location where the bottom of the feeder adjoins the casting, marked in all cases with an X. Hence it is of vital importance that the feeding rods in all cases should nearly reach the core when commencing to feed. Of course, hot feeding iron should always be available.

These large feeders have many times been the means of saving the casting from causes that may occasionally happen, such as dull iron, slow pouring, a run-out, or scabbing.

It is admitted that it is ugly, and sometimes inconvenient to remove, but use becomes second nature. The feeder is drilled with a few holes

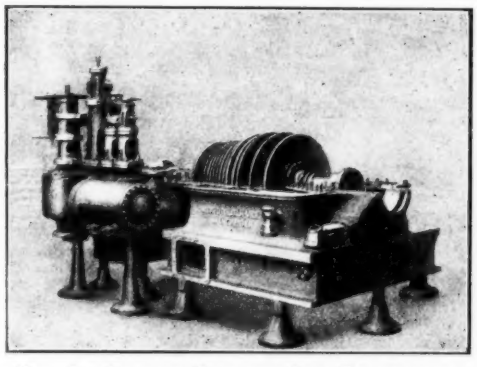


FIG. 2.—ON THIS TYPE THE SIDE FRAMES AND BOTTOM HALF OF THE CYLINDER ARE CAST IN ONE PIECE.

and afterwards tapped or drifted off, the parting place being planed as the casting is passing through other machining operations. In the early days and without exception all castings failing on pressure test at this place were due to, and caused by, an accumulation of scum, dirt, etc., during pouring which was unable to make its escape.

When the feeding has been done intelligently the writer has not known a failure, and since its adoption some hundreds of turbine cylinders have passed through the pressure test.

At one period it was an exception when a turbine cylinder passed through the test without a leak. Now it is the reverse, the exception being when one does not pass through.

All foundry troubles and their obviation have not been dealt with in so far as they relate to turbine cylinders.

Soldering Aluminium Castings.

Hitherto the only possible means of repairing an aluminium casting has been by the welding process, either oxy-acetylene or electric.

The welding process was adopted simply because there was no alternative. It could certainly never be regarded as a sound mechanical proposition; too often, indeed, it was not even sound commercially, as it not only called for the use of a costly plant but also for the employment of highly skilled labour.

Under the best conditions there is a considerable element of risk attending the repair of shaped castings by the welding process. In the first place, the parts to be welded have to be heated to a plastic condition, which cannot but result in more or less distortion. Pure aluminium wire and a flux have to be employed. Obviously, with the weld made of pure aluminium and the body of the job an alloy there must be two contractions, and, further, a certain amount of oxidation due to the flux is unavoidable.

It was a consideration of the foregoing, combined with a recognition of the fact that the repair of aluminium castings becomes each day a more pressing necessity that led Mr. W. V. Neal to experiment with other methods than welding for effecting such repairs, and, after many years of patient research and costly experiment, he has perfected a solder for the repair of every description of aluminium. The use of this solder, which is being placed upon the market by the Nesol Aluminium Solder Company, John Dalton Street, Manchester, not only eliminates the whole of the troubles incidental to the welding process, but places the repair of an aluminium casting within the scope of the village plumber.

As the flux is a component part of the solder, nothing more than the blow lamp and iron is

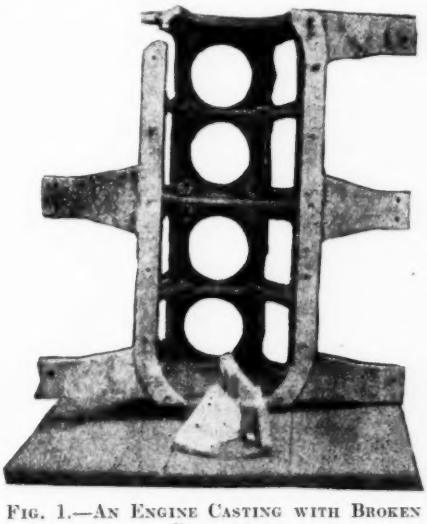


FIG. 1.—AN ENGINE CASTING WITH BROKEN BRACKET.

required to effect the repair. The solder melts and the flux becomes active at a temperature of 300 deg. C., a temperature at which the casting is, of course, solid, so that there is no possibility of distortion. Naturally the cost of making such a repair is only a fraction of that for the welding process. That the economy, however, does not end there was made evident when our representative recently visited the Denton Works, Manchester, of Messrs. W. V. Neal & Company. A "Peerless" engine from a 5-ton lorry had just been brought in to be fitted with a new magneto bracket. The engine had simply been lifted bodily

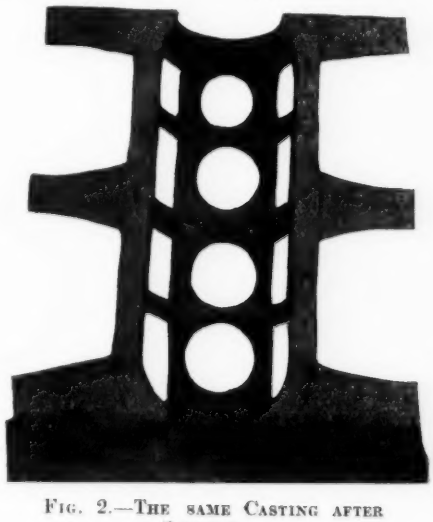


FIG. 2.—THE SAME CASTING AFTER SOLDERING.

off the chassis and the new bracket was soldered into position on the casing without any dismantling of the engine, so that the whole could be then lifted back on to the chassis and the lorry driven away. This might well mean more than a saving of time, as when one comes to strip an engine which has done considerable service, let that engine be running never so well prior to the stripping, adjustments and repairs will often be necessary on re-assembly.

Most minor repairs could, of course, be done at the works, whilst a considerable field of usefulness could be found for the solder in the aluminium foundry.

XUM

Trade Talk.

EIGHTY-FIVE resolutions are on the agenda for the 57th Annual Trades Union Congress, to be held at Scarborough on September 7, and the five following days. The action taken by the General Council during the coal crisis will come up for discussion on the report of the council.

A TRUST DEED, dated July 31, to secure £1,000,000 debenture stock, has been registered by the Mond Nickel Company, Limited, Lombard Street, E.C. In order to redeem the outstanding Eight per cent. Debentures, to repay loans and to provide for extensions. An issue of five and a-half per cent. debentures was made in July, together with an issue of preference shares.

ARRANGEMENTS have been made by Mr. J. R Venning for the formation of a limited company for the purpose of acquiring the goodwill of the sanitary equipment and sanitary engineering department of Messrs. Mellowes & Company, Limited, Sheffield, to carry the same on upon similar lines as heretofore as from August 1, 1925. Mr. Venning has for some time been connected with that particular department.

MR. WILL SHERWOOD, of the National Union of General and Municipal Workers, dealing with the shipbuilding depression, states in a circular to his members that the shipowners out of their capital reserves could condemn their obsolete vessels and place orders for new ships, so that we could again become the carriers of the world. Reducing wages and lengthening hours were no remedies, but the following would tend to a revival :—Change the methods of production, extend the payment-by-results system—especially to platers' helpers—abolish certain craft anomalies, learn the real financial position of shipbuilding concerns, and write down their capital to its real value.

THE Société Métallurgique de Normandie report that their hematite ore output had increased from 23,770 tons in 1921 to 61,360 tons in 1922, but fell off again to 54,595 tons in 1924. Their output of roasted carbonate ore, on the other hand, gradually increased from 64,600 tons to 138,905 tons in 1924. Their iron and steel output increased as follows: Pig-iron, from 158,000 tons in 1921 to 212,000 tons in 1924; steel ingots from 133,000 tons to 271,000 tons in the same period of four years; the output of rolled products increased from 108,000 tons in 1921 to 212,000 tons in 1923, but declined to 204,000 tons last year. A large part of their iron and steel output was, as usual, sold in Great Britain.

THE STATISTICAL SUMMARY of ships totally lost, broken up, condemned, etc., published by Lloyd's Register, shows that, during 1924, the gross reduction in the mercantile marine of the world amounted to 1,016 ships of 1,857,679 tons, excluding all ships of less than 100 tons. Of this total, 777 ships of 1,614,662 tons were steamers and motor-ships, and 239, of 243,017 tons, were sailing ships. These figures, compared with those for 1923, show an increase of 157,792 tons as regards steamers and motor-ships, but a decrease of 16,892 tons for sailing ships—the net increase for 1924 being 140,900 tons. This total increase is not due to actual casualties—the figures for which show a decrease of 53,900 tons for steamers and motor-ships—but to the large amount of tonnage broken up during 1924, viz., 1,326,134 tons. This tonnage exceeds the similar figures for 1923 by 185,927 tons, and is the highest ever recorded. The tonnage of ships, owned in Great Britain and Ireland, which were broken up, dismantled, etc., during 1924, amounted to 261,575 tons.

IN CONNECTION WITH THE SALVAGE WORK being carried out at Scapa Flow to recover the sunken German warships, Messrs. Cox & Danks, Limited, have recently purchased in public tender from the British Admiralty one of the two 40,000-ton floating docks which were surrendered from Germany, and will have one of the six sections towed to Scapa. This section of the dock, which is in itself an enormous piece of marine construction, is leaving this firm's shipbreaking yard at Queenborough this week. The floating dock, one of the largest in the world, is over 700 ft. long and 200 ft. broad. Certain alterations have been carried out on the section which is being transferred, so that when one side wall is cut clean away and a 30-ft. square cut in the opposite wall, it can be put into service as a dry dock. It is for this purpose that it is being towed north. Up to the present the work of salvage has proceeded according to plan, so that at the present time Gutter Sound is practically clear for navigation. Seventeen destroyers have already been raised, and the next one to be dealt with lies on the island of Fara. She is in shallow water and is upside down. It is expected that by the spring all the 26 destroyers will have been recovered. Nothing has yet been done towards beginning on the "Hindenburg" and the "Seydlitz," although preparation for the provision of plant is being considered in readiness for a start in the spring.

Contracts Open.

Alexandria, Egypt, October 30.—Motor-boats, etc., for the Egyptian Quarantine Board. The Department of Overseas Trade. (Ref. A.X. 2,341.)

Athens, September 24.—Steam vessels, etc., for the Greek Government. The Greek Legation, 51, Upper Brook Street, London, W.1.

Barnsley, October 1.—Supply and setting to work of three oil engines (approximately 25-b.h.p. each) and pumps for the Corporation. The Waterworks Engineer, Doncaster Road, Barnsley. (Fee £5, returnable.)

Chester.—130 tons of 15-in. cast-iron socket pipes, in accordance with the British standard specifications, for the Chester Waterworks Company. Mr. W. S. Moss, secretary and manager, Waterworks Offices, 15, Newgate Street, Chester.

Darlington, September 10.—Iron and steel, etc., for six months ending March 31, 1926, for the Corporation. The Borough Surveyor and Waterworks Engineer, Town Hall, Darlington.

London, S.W., September 15-October 1.—Steelwork, etc., for the Madras and Southern Mahratta Railway Company, Limited. 25, Buckingham Palace Road, London, S.W.1. (Fee £1 1s., non-returnable.)

Okehampton, September 14.—Supplying, laying and jointing of about 1,340 yards of 6-in. and 290 yards of 4-in. cast-iron socket pipes, with all necessary sluice valves, hydrants and other works, for the Town Council. Nichols and Unwin, 13, Victoria Street, Westminster, London, S.W.1. (Fee £2, returnable.)

Swansea.—Supply of portable compressor and all tools, gear, etc. Mr. B. Hinds, "Nether Edge," Glanyrafon Road, Sketty, Swansea.

Wellington, N.Z., January 5.—Three electric centrifugal sewage pumping plants for the Christchurch Drainage Board. The Department of Overseas Trade. (Ref. A.X. 2,349.)

Uxbridge, September 14.—About 1,000 yards run of straight and curved vertical iron fencing for the U.D.C. The Surveyor, Mr. W. L. Eves, 54, High Street, Uxbridge.

York, September 5.—Iron and steel, etc., during six months October 1, 1925, to March 31, 1926, for the Corporation. The City Engineer's Office.

Company News.

Murray McBride & Company, Limited, 57, Oswald Street, Glasgow.—Capital £2,000 in £1 shares. Engineers.

Dalmellington Iron Company, Limited.—Final dividend of 1s. per share, tax free, on ordinary, making 7½ per cent., tax free, for the year.

Baker & Company (Doncaster), Limited, 27, High Street, Doncaster.—Capital £2,000 in £1 shares. Engineers. Directors: Dr. E. J. Chambers, E. Baker and A. Baker.

Beardmore (Paisley), Limited.—Capital £250,000 in £1 shares. Engineers. Directors: Rt. Hon. Lord Invernairn of Strathnairn, V. Beardmore Stewart, and John G. Girdwood.

Gregson and Partners, Limited.—Capital £10,000 in £1 shares. Chemical engineers. Directors: E. P. Taudevin, 74, Endcliffe Edge, Sheffield; W. Gregson and J. O. Taudevin.

Mole & Beddall, Limited.—Capital £2,000 in £1 shares. Chain manufacturers. Directors: J. G. Mole, Westbourne, Cradley, Staffs.; G. A. Beddall, 72, Grange Lane, Stourbridge.

Blanchard & Lovelace, Limited, Railway Works, Railway Street, Grimsby. — Capital £10,000 in £1 shares. Iron and brass founders, etc. Directors: H. Blanchard and J. C. Lovelace.

G. Bobcock & Company, Limited, 115, Colmore Row Birmingham.—Capital £5,000 in £1 shares. Metal dealers. Directors: H. P. Bobcock, Mrs. Elsie M. Woodhouse and G. Squiers.

General Construction Company, Limited, 20, Copthall Avenue, London, E.C.2.—Capital £15,000 in £100 shares. Engineers, etc. Directors: C. A. Moreing, A. H. Moreing and N. W. Diggle.

Walter Scott (Limited).—Trading of £16,985 for the year ended June 30; surplus of £4,286 brought forward; directors' fees, £1,000; debenture interest, £12,000; adverse balance forward, £25,699.

Elliot & Jeffrey, Limited.—Capital £60,000 in £1 shares. Shipbuilders. Directors: John Elliot, 166, Newport Road, Cardiff, and Thos. Elliot. Solicitors: Gilbert Robertson & Company, P.O. Chambers, Bute Docks, Cardiff.

William G. Thomas & Frazer Nash, Limited, Sardinia House, Kingsway, London, W.C.2.—Capital £11,000 in 10,000 10 per cent. cumulative participating preference shares of £1 each and 20,000 ordinary shares of 1s. Motor engineers. Directors: W. G. Thomas and A. G. F Nash.

MACNAB & CO.

Tabor Patent Portable Combination "Shockless" Jarring Roll-over and Pattern-Drawing

MOULDING MACHINE.

BRITISH BUILT

Box and Mould—after being Rammed—in position of being Rolled over.

Special Features and Advantages.

Sand jar rammed by "Shockless" device—Tabor Patent—without shock to the machine or surrounding moulds.

*** Machine not restricted to use of one size moulding box—any size can be used up to load capacity of machine.**

Good surface castings.

Pattern plates can be changed instantly without unfastening mechanism so that comparatively small quantities can be made economically.

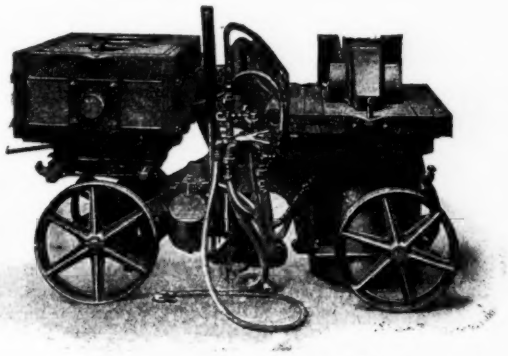
Perfectly straight draw ensured by mechanical guides of large surface to prevent wear and retain accuracy.

All moulds jar rammed in a few seconds and thoroughly uniform in density, ensuring minimum quantity of defective castings and less blow holes.

"All operations other than sand filling are completed in two minutes for any size of work within capacity of machine. To realise what this means, compare your present wage cost for the same work!"

CAPACITY.

SIZE	* Size of Moulding Box.	Straight Pattern Draft.	Nett Weight of load that can be rolled over at 80lbs. pressure.
18	18 in. wide. 36 in. long. 12 in. deep.	8 in.	450 lbs.
24	24 in. wide. 48 in. long. 15 in. deep.	10 in.	800 lbs.



The Finished Mould—showing Pattern after being drawn.

We make various models and sizes for all types of machine moulding, according to class of work and numbers.

SEND US DRAWINGS OF YOUR WORK FOR SPECIFIC EXPERT ADVICE, ... ACCORDING TO YOUR CONDITIONS AND QUANTITIES. .. ..

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IRON AND STEEL MARKETS.

Pig-iron.

MIDDLESBROUGH.—With the opening of September, and the general resumption of business after the holiday season, the tone of the Cleveland iron market has developed a more cheerful note, and some fair sales have been effected for home consumption. The bulk of the transactions recorded is, however, of comparatively small dimensions, buyers still anticipating a further fall in prices, and preserving their previous cautious attitude until something like finality is reached in the downward progress of quotations. With imported iron now available at considerably lower figures than Tees-side makes, home smelters have still some leeway to make up in this direction, but now that a substantial reduction in fuel costs is in view, it is confidently expected that Cleveland quotations may soon be decreased to something like competitive levels. Current quotations now rule as follow:—No. 3 G.M.B., 69s. per ton; No. 1, 73s.; No. 4 foundry, 68s.; and No. 4 forge, 67s. 6d. per ton.

The market for hematite is undoubtedly steadier, and the long-continued decline in quotations would seem to have been definitely arrested, at all events, on the present basis of output. The improvement in the Italian exchange is a welcome feature. East Coast mixed numbers were held quite firmly at last week's market at 75s. 6d. per ton, at which figure they have remained unchanged for several weeks. The No. 1 quality is 76s. per ton. On the North-West Coast prices are unchanged, with Bessemer mixed number nominally £4 5s., c.i.f. Welsh ports, £4 6s. 6d. per ton delivered at Glasgow, £4 12s. 6d. per ton delivered at Sheffield, and £4 15s. per ton delivered at Birmingham.

LANCASHIRE.—Markets for foundry iron in this area remain dull and inactive, with prices inclined in a downward direction. As a rule, Derbyshire No. 3 iron is now based on 67s. 6d. per ton at the furnaces, so that there has been a fall of 2s. 6d. per ton since the coal settlement was made. Northamptonshire iron is quoted now at 62s. 6d. per ton on trucks, but the excessive carriage prevents it from being sold in any quantity in the Manchester district. The local demand for Scotch foundry iron is only very small, but the price has not been altered for some six weeks or more. Hence the gap between the common Midland quality and Scotch becomes wider, and there is now more than 20s. per ton difference in Lancashire.

THE MIDLANDS.—There is very little animation in the Birmingham market, and consumers are quite content to continue as they have been doing for some weeks, and confine their purchases to small quantities sufficient to carry on week by week. The lowest price for Derbyshire No. 3 foundry appears to be 67s. 6d. at furnaces, some of the makers demanding 1s. per ton more than this, whilst No. 3 Northants. iron is quoted at 62s. 6d. and 63s. f.o.t. Staffordshire No. 3 is still 70s. per ton.

SCOTLAND.—The Scotch pig-iron market continues very quiet, and makers' prices are easy at 80s. 6d. for No. 3 foundry at the furnaces. There is very little inquiry, however, and merchants compete keenly for any orders which appear on the market. For Middlesbrough iron there is also a very poor demand, and prices here have eased to 73s. 6d. for No. 3 at Grangemouth.

Finished Iron.

Very little improvement can be noted in the business passing in this section of the industry with the exception of the manufacturers of marked bars, who are moderately active with fairly filled order books. There is, however, plenty of competition amongst the crown bar-iron makers for the scant volume of business available. The nominal price of the Associated makers is £12 7s. 6d. per ton, but they can reduce this figure when occasion demands in order to meet the outside makers' price. The position is even worse with the works producing nut and bolt and fencing irons, for it is here that the brunt of the Continental competition is felt. The French and Belgian works are quoting for this grade of iron prices between £6 15s. and £7 per ton delivered here, whilst the local product is £11 7s. 6d. per ton. With such a disparity, only a little tonnage falls to the lot of the local makers.

Steel.

Conditions in the Sheffield steel market continue quiet, with prices again inclined to lower levels. There is scarcely any inquiry for billets, either acid or basic, and the recent cut in prices has not had the effect up to the present of helping business. The steel trade generally is at a low level. The output of the open-hearth furnaces is above sales, and unless business improves it is fairly certain that further plants will go out of operation. Sales of Swedish steel have dropped heavily in the last few weeks. There is very little business passing in ferro-manganese just now. The French position is unaltered, but American buying is reported to have slightly improved, although the volume remains restricted. Business in the tinplate market continues unsettled on account of the uncertainty which prevails with regard to the future policy of price stabilisation. For ordinary sizes 19s. 4½d. has been done for forward delivery.

Scrap.

Reports from the various markets for scrap material continue disappointing, the demand for foundry metal especially being notably diminished, with prices almost uniformly weaker. Lancashire buyers of cast-iron scrap for foundry work are influenced by the low prices of common pig-iron. In Manchester 75s. for this is now the highest price paid, and ironfounders think that they ought to get scrap at 5s. less, if not at a lower price. Holders of broken machinery metal ask for 72s. 6d. delivered, but there are enough weak sellers to enable the foundries to buy at 70s., except for special qualities from broken loom machinery. For the latter 80s. per ton is asked, and sometimes 82s. 6d., and if it can be used in place of Scotch iron this is a favourable price. In Scotland machinery cast-iron scrap shows no improvement, and parcels are now being offered at 72s. 6d. to 75s. per ton, but with little result, as foundries are not in the market meantime. Ordinary cast-iron scrap is in the same position at about 5s. per ton less. Light cast iron and firebars remain unchanged at 55s. to 56s. 3d. per ton. The above prices are all per ton delivered f.o.t. consumers' works.

Metals.

Copper.—Although somewhat lower levels have been reported in values of standard metal, the tone of the market continues steady without the violent fluctuations usually marked at periods of speculative activity. Towards the end of the previous week reports were current of a reduction in the American stocks of rough and refined copper, notwithstanding the fact that the export movement during July showed some contraction. This is confirmatory evidence of the fact that the recent upward movement in values is attributable more to buying on the part of interests in the United States than of those in Europe.

Current quotations :—*Cash* : Thursday, £62 2s. 6d.; Friday, £62; Monday, £61 15s.; Tuesday, £61 12s. 6d.; Wednesday, £61 15s.

Three Months : Thursday, £63 2s. 6d. : Friday, £63; Monday, £62 15s.; Tuesday, £62 12s. 6d.; Wednesday, £62 15s.

Tin.—The recent further downward reaction in tin has been doubtless due not only to the continued abstention of American buying, but also to the liquidation of stale bull commitments. A certain amount of bear selling has also been in evidence, in view of the fact that the August shipments from the Straits, which totalled over 4,000 tons for the first half of the month, will probably be heavier than had been generally expected. Estimates range up to about 6,800 tons. Eastern sales were maintained on a rather modest scale, from which there was a rally following an improved demand from home and American importers.

Current quotations :—*Cash* : Thursday, £254 10s.; Friday, £253 7s. 6d.; Monday, £251 17s. 6d.; Tuesday, £250 5s.; Wednesday, £251 10s.

Three Months : Thursday, £257 5s.; Friday, £256 5s.; Monday, £254 17s. 6d.; Tuesday, £253 2s. 6d.; Wednesday, £254 5s.

Spelter.—There is little or no change in the zinc situation as it has been recently defined by Rudolf Wolff. Demand on the part of consumers has, perhaps, slightly improved. Galvanisers are said to be fairly well occupied, and, at the same time, spelter producers are reported to be comfortably sold and have held off the market, and metal has, generally speaking, been only sparsely offered.

Current quotations : — *Ordinary* : Thursday, £36 17s. 6d.; Friday, £36 16s. 3d.; Monday, £36 16s. 3d.; Tuesday, £36 10s.; Wednesday, £36 13s. 9d.

Lead.—The tendency of soft foreign pig of late has developed further strength, with values advanced for near and forward delivery. Consumers are reported to have bought freely, and advancing prices have induced some bear covering. Furthermore, reports from the United States, where a further advance to 9.40 cents has been established, have been consistently strong, and metal, therefore, offered for sale has not been commensurate with the heavy demand which has arisen.

Current quotations :—*Soft foreign (pormpt)* : Thursday, £39 5s.; Friday, £39 2s. 6d.; Monday, £38 17s. 6d.; Tuesday, £39 10s.; Wednesday, £38 7s. 6d.

BLACKING,
PLUMBAGO,
CORE GUM,
WHITE DUST,
COAL DUST.

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JAS. DURRANS & SONS, LTD.

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FOUNDRY EQUIPMENTS

LADLES,
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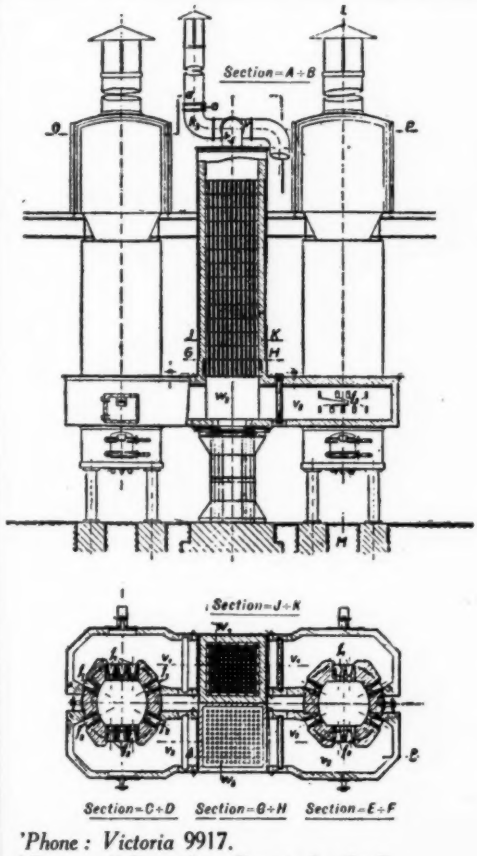

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SCHURMANN (PATENT) SIDE BLAST CUPOLA WITH REVERSING REGENERATORS

BY INSTALLING THE "SCHURMANN" REGENERATOR TO YOUR EXISTING CUPOLA YOU CAN OBTAIN HOTTER METAL, A LARGE REDUCTION IN CHARGE COKE & SULPHUR CONTENT, INCREASED OUTPUT & LONGER LIFE OF CUPOLA LINING.

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BRITISH SCHURMANN CUPOLA & FOUNDRY EQUIPMENT Co. Ltd.

15, VICTORIA ST., LONDON, S.W.1

WEEKLY PRICE CURRENT.

COPPER.

	£	s.	d.
Standard cash	61	15	0
Three months	62	15	0
Electrolytic	67	5	0
Tough	64	10	0
Best selected ..	65	0	0
Sheets	92	0	0
India	81	5	0
Wire bars ..	67	5	0
Do. Sept.-Oct.	66	15	0
Do. Nov.	67	5	0
Ingot bars ..	66	15	0
H.C. wire rods	71	10	0
Off. av. cash, Aug.	62	13	6
Do., 3 mnths. Aug.	63	13	0
Do. Sttlmnt, Aug.	62	13	4½
Do., Electro, Aug.	68	7	9
Do., B.S., Aug.	66	3	1½
Aver. spot price copper, Aug.	62	13	4½
Do., wire bars, Aug.	68	12	1½
Solid drawn tubes		13½d.	
Brazed tubes ..		13½d.	
Wire		10d.	

BRASS.

Solid drawn tubes	12d.
Brazed tubes ..	13½d.
Rods, drawn ..	10¾d.
Rods, extd. or rlld.	7½d.
Sheets to 10 w.g.	10¾d.
Wire	10¾d.
Rolled metal ..	9¾d.
Yellow metal rods	7½d.
Do. 4 x 4 Squares	8d.
Do. 4 x 3 Sheets	8½d.

TIN.

Standard cash	251	10	0
Three months ..	254	5	0
English ..	251	15	0
Bars	253	15	0
Straits	257	10	0
Australian ..	255	0	0
Eastern ..	259	0	0
Banca	257	10	0
Off. aver. cash, Aug.	258	12	8½
Do., 3 mths., Aug.	258	6	6¾
Do., Sttlmnt. Aug.	258	13	0
Aver. spot., Aug.	258	13	0

SPELTER.

Ordinary ..	36	13	9
Remelted ..	36	0	0
Hard	30	5	0
Electro 99.9 ..	40	17	6
English ..	37	0	0
India	31	5	0
Zinc dust ..	43	0	0
Zinc ashes ..	14	10	0
Off. aver., Aug.	36	9	1½
Aver., spot, Aug.	36	13	9

LEAD.

Soft foreign ppt.	38	7	6
English ..	39	15	0
Off. average, Aug.	37	8	4½
Average spot, Aug.	38	3	9

ZINC SHEETS, &c.

Zinc sheets, English	43	0	0
Do. V.M. ex whf.	42	15	0
Rods	49	0	0
Boiler plates ..	41	10	0
Battery plates	42	0	0

ANTIMONY.

Special brands, Eng.	74	10	0
Chinese ..	64	10	0
Crude	53	0	0

QUICKSILVER.

Quicksilver ..	13	10	0

FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro silicon 45/50% ..	12	12	6
75%	21	5	0
Ferro-vanadium— 35/40% ..	16/6 lb. va		
Ferro-molybdenum— 70/75% c. free	7/- lb.		
Ferro-titanium— 23/25% carbonless	1/- lb.		
Ferro-phosphorus, 20/25%,	£22	0	0
Ferro-tungsten— 80/85%, c.fr.	1/7½ to 1/8 lb.		
Tungsten metal powder— 98/99% ..	1/11 lb.		
Ferro-chrome— 4/6% car. ..	£23	10	0
6/8% car. ..	£23	0	0
8/10% car. ..	£22	10	0
Ferro-chrome— Max. 2% car.	£42	10	0
Max. 1% car.	£52	0	0
Max. 0.70% car.	£56	10	0
70%, carbonless	1/5 lb.		
Nickel—99%, cubes or pellets	£170 to £175		
Cobalt metal—98/99%	10/3 lb.		
Aluminium 98/99%	£118		
Metallic Chromium— 96/98% ..	3/9 lb.		
Ferro-manganese (net)— 76/80%, loose	£15	7	6
76/80%, packed	£16	7	6
76/80%, export	£15	5	0
Metallic manganese— 94/96%, carbonless	2/- lb.		

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten ..	s. d. 2 6
Finished bars, 18% tungsten ..	3 0

Per lb. net, d/d buyers' works.

Extras—

Rounds and squares 3 in. and over ..	4d. lb.
Rounds and squares under ½ in. to ¼ in.	3d. lb.
Do. under ¼ in. to ⅛ in.	1/- lb.
Flats, ½ in. × ⅛ in. to under 1 in. × ⅛ in.	3d. lb.
Do. under ½ in. × ⅛ in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.
Bars cut to length	10% extra

Scrap from high-speed tool steel—

Scrap pieces ..	3d.
Turnings and swarf	1d.

Per lb. net, d/d steel makers' works.

SCRAP.

South Wales—	£	s.	d.	£	s.	d.
Hvy, steel				3	5	0
Bundled steel &shrngs.	3	0	0 to	3	3	6
Mixed iron & steel	3	0	0 to	3	2	6
Heavy cast iron	3	0	0 to	3	7	6
Good machinery for foundries	3	10	0 to	3	15	0
Cleveland— Heavy steel ..				2	17	6
Steel turnings ..				2	4	6
Cast-iron borings				2	0	0
Heavy forge ..				4	0	0
Bushelled scrap				3	5	0
Cast-iron scrap				3	11	0
Lancashire— Cast-iron scrap ..				3	12	6
Heavy wrought	3	10	0 to	3	12	6
Steel turnings ..				2	5	0

London — Merchants' buying prices delivered yard.

Copper (clean) ..	53	0	0
Brass (clean) ..	40	0	0
Lead (less usual draft)	36	0	0
Tea lead ..	30	0	0
Zinc	24	0	0
New aluminium cuttings ..	95	0	0
Braziery copper	48	0	0
Gunmetal ..	48	0	0
Hollow pewter ..	180	0	0
Shaped black pewter	130	0	0

PIG-IRON.

(f.o.t. unless otherwise stated).

N.E. Coast— Foundry No. 1 ..	73/-
Foundry No. 3 ..	69/-
Foundry No. 4 ..	68/-
Forge No. 4 ..	67/6
Hematite No. 1 ..	76/-
Hematite M/Nos. ..	75/6
N.W. Coast— Hem. M/Nos. d/d Glas.	86/6
,, d/d Birm. ..	95/-
Midlands— Staffs. common* ..	102/-
,, No. 4 forge ..	67/6
,, No. 3 foundry	70/-
Shrops. basic ..	75/-
,, Cold blast, ord.*	190/-
,, ,, roll iron*	195/-
* d/d Birmingham.	
Northants forge ..	57/6
,, fdry No. 3 ..	62/6
Derbyshire forge ..	59/-
,, fdry No. 3 ..	67/6
,, basic	72/6
Scotland— Foundry No. 1 ..	85/6
,, No. 3 ..	80/6
Hem. M/Nos. ..	82/-
Sheffield (d/d district)— Derby forge ..	63/-
,, fdry. No. 3 ..	71/6
Lincs. forge ..	69/-
,, fdry. No 3 ..	72/-
E.C. hematite ..	85/6
W.C. hematite ..	90/-
Lincs. (at furnaces)— Forge No. 4 ..	63/-
Foundry No. 3 ..	66/-
Basic	66/-
Lancashire (d/d eq. Man.)— Derby forge ..	66/6
,, fdry. No. 3 ..	70/-
Northants foundry No. 3 ..	75/6
Dalzell, No. 3 ..	111/-
Summerlee, No. 3 ..	98/-
Glengarnock, No. 3	98/-
Gartsherrie, No. 3 ..	98/-
Monkland, No. 3 ..	98/-
Coltness, No. 3 ..	98/-
Shotts, No. 3 ..	98/-

FINISHED IRON AND STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

Iron—	£	s.	d.	£	s.	d.
Bars (cr.)	11	12	6 to	12	10	0
Angles		12	7	6		
Tees to 3 united ins		13	2	6		
Nut and bolt		11	7	6		
Hoops	14	0	0 to	15	0	0
Marked bars (Staffs.) f.o.t. ..		14	10	0		
Gas strip ..		12	15	0		
Bolts and nuts, ¾ in. × 4 in. ..		16	15	0		
Steel— Ship plates	8	0	0 to	8	15	0
Boiler plts.	£12	10	to	13	0	0
Chequer plts.	£	9	15 to	10	5	0
Angles	£7	15	0 to	8	5	0
Tees	£9	0	0 to	9	5	0
Channels	£7	7	6 to	7	17	6
Joists	£7	15	0 to	8	5	0
Rounds and Squares 3in. to 5½in. ..		9	5	0		
Rounds under 3 in. to ¾ in... ..		9	0	0		
Flats, over 5 in. wide and up ..		9	15	0		
Flats, 5in. to 1½in.		8	15	0		
Rails, heavy ..		8	10	0		
Fishplates ..		12	10	0		
Hoops (Staffs.)	£11	0	0 to	11	10	0
Black sheets, 24g.		11	10	0		
Galv. cor. sheets, 24g.		16	5	0		
Galv. fencing wire 8g. plain ..		14	0	0		
Billets, soft	6	10	0 to	7	15	0
Billets, hard ..		9	0	0		
Sheet bars	6	10	0 to	6	15	0
Tin bars d/d	6	10	0 to	6	15	0

PHOSPHOR BRONZE

	Per lb.	basis.
Strip	1	3
Sheet to w.g. ..	1	3½
Wire	1	4
Rods	1	3
Tubes	1	8
Castings	1	2

Delivery 3 cwt. free.
10% phos. cop. £40 above B.S.
15% phos. cop. £50 above B.S
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	9d. to 1/3
Rolled— To 9 in. wide	1/3 to 1/9
To 12 in. wide	1/3½ to 1/9½
To 15 in. wide	1/3½ to 1/9½
To 18 in. wide	1/4 to 1/10
To 21 in. wide	1/4½ to 1/10½
To 25 in. wide	1/5 to 1/11
Ingots for spoons and forks	9d. to 1/5½
Ingots rolled to spoon size	1/- to 1/8½
Wire round— 3/0 to 10 G. ..	1/6½ to 2/1½

with extras according to gauge.

AMERICAN IRON & STEEL.

At Pittsburgh unless otherwise stated.

	Dols.
No. 2X foundry, Phila.	21.76
No. 2 foundry, Valley	20.26
No. 2 foundry, Birm.	18.00
Basic	19.76
Bessemer	20.76
Malleable	20.26
Grey forge	19.76
Ferro-mang. 80% d/d	115.00
Bess. rails, h'y, at mill	43.00
O.-h. rails, h'y at mill	43.00
Bess. billets	35.00
O.-h. billets	35.00
O.-h. sheet bars ..	35.00
Wire rods	45.00
	Cents.
Iron bars, Phila. ..	2.17
Steel bars	1.90
Tank plates	1.80
Beams, etc.	1.90
Skelp, grooved steel ..	1.90
Skelp, sheared steel ..	1.90
Steel hoops	2.40
Sheets, black, No. 28 ..	3.15
Sheets, galv., No. 28 ..	4.20
Sheets, blue an'l'd, 9 & 10	2.30
Wire nails	2.65
Plain wire	2.50
Barbed wire, galv. ..	3.35
Tinplate, 100 lb. box ..	$5.50

COKE (at ovens).

Welsh foundry ..	37/6
,, furnace	27/6
Durham & North. ,, foundry ..	35/-
,, furnace ..	15/-
Other Districts, foundry	35/-
,, ,, furnace (Basis)	13/6

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. Cokes, 20 × 14, box	19/4½
,, 28 × 20, ,,	39/6
,, 20 × 10, ,,	28/3
,, 18¾ × 14, ,,	20/1½
C.W. 20 × 14, ,,	17/7½
,, 28 × 20, ,,	35/3
,, 20 × 10, ,,	24/6
,, 18¾ × 14, ,,	18/-

Terneplates 28 × 20, 35/6 per box basis f.o.b.

SWEDISH IRON.

Bars, hammered	£19/0 to £20/0
Rolled Ord.	£16/0/0 to £16/10/0
Nail rods	16 5 0 to £16 15 0
Keg. steel nom.	£33 to £35
Faggot steel nom.	£22 to £25
Blooms, according to quality	£10 to £14
Pig-iron	£6 15 0 to £7 0 0

all f.o.b. Gothenburg.

TUBES.

	Up to and incl. 6 in.	
Gas	55%	Tube prices are now free.
Water	50%	
Steam	45%	

DAILY FLUCTUATIONS.

Standard Copper (Cash).

	£	s.	d.	
Aug. 27	62	2	0	dec. 2/6
,, 28	62	0	0	,, 2/6
,, 31	61	15	0	,, 5/-
Sept. 1	61	12	6	,, 2/6
,, 2	61	15	0	inc. 2/6

Electrolytic Copper.

	£	s.	d.	
Aug. 27	67	15	0	dec. 7/6
,, 28	67	5	0	,, 10/-
,, 31	67	5	0	No change
Sept. 1	67	0	0	,, 5/-
,, 2	67	5	0	inc. 5/-

Standard Tin (cash).

	£	s.	d.	
Aug. 27	254	10	0	dec. 35/-
,, 28	253	7	6	,, 22/6
,, 31	251	17	6	,, 30/-
Sept. 1	250	5	0	,, 32/6
,, 2	251	10	0	inc. 25/-

Tin (English ingots).

	£	s.	d.	
Aug. 27	254	15	0	dec. 45/-
,, 28	253	15	0	,, 20/-
,, 31	252	5	0	,, 30/-
Sept. 1	250	10	0	,, 35/-
,, 2	251	15	0	inc. 25/-

Zinc Sheets (English).

	£	s.	d.	
Aug. 27	42	10	0	No change
,, 28	42	10	0	,, ,,
,, 31	42	10	0	,, ,,
Sept. 1	43	0	0	inc. 10/-
,, 2	43	0	0	No change

Spelter (ordinary).

	£	s.	d.	
Aug. 27	36	17	6	inc. 1/3
,, 28	36	16	3	dec. 1/3
,, 31	36	16	3	No change
Sept. 1	36	10	0	dec. 6/3
,, 2	36	13	9	inc. 3/9

Lead (English).

	£	s.	d.	
Aug. 27	40	15	0	dec. 5/-
,, 28	40	5	0	,, 10/-
,, 31	40	0	0	,, 5/-
Sept. 1	40	0	0	No change
,, 2	39	15	0	dec. 5/-

Germany.—Exports from Germany and Luxemburg.

Year.	Ingots, blooms, billets, etc.	Rails.	Sleepers, etc.	Wheels, axles, tyres, etc.	Merchant iron and steel.	Sheets and plates.	Tinplates.	Total iron and steel, including unenumerated.
	Metric tons.	Metric tons.	Metric tons.	Metric tons.	Metric tons.	Metric tons.	Met. tons	Metric tons.
1887 ..	40,135	174,226	21,553	20,447	250,632	57,992	248	565,223
1888 ..	22,293	114,946	23,254	20,808	235,429	67,895	377	485,002
1889 ..	20,808	110,949	26,042	26,030	218,024	63,717	297	465,867
1890 ..	24,141	130,837	26,470	29,114	195,078	60,604	422	476,666
1891 ..	42,458	142,846	63,406	33,554	268,134	64,158	417	614,973
1892 ..	37,184	113,712	39,558	26,554	283,393	58,037	341	558,779
1893 ..	55,565	87,360	37,487	29,714	338,927	70,532	538	620,123
1894 ..	41,993	119,410	43,343	24,318	431,161	93,288	317	752,830
1895 ..	61,808	116,627	45,619	25,824	451,141	128,510	284	829,813
1896 ..	49,529	129,413	52,163	24,750	438,348	135,472	135	829,510
1897 ..	39,792	113,473	31,189	29,331	416,060	138,057	274	768,176
1898 ..	34,964	123,839	30,803	31,724	468,403	157,639	165	847,534
1899 ..	23,438	109,813	30,383	40,703	415,098	157,633	113	777,181
1900 ..	33,267	155,656	39,492	46,875	388,174	174,658	238	838,360
1901 ..	201,716	180,978	42,710	49,257	671,960	263,755	158	1,410,534
1902 ..	636,716	366,815	48,960	47,491	743,453	283,507	150	2,126,803
1903 ..	638,182	378,611	73,099	48,305	768,484	293,046	177	2,199,984
1904 ..	395,990	210,049	68,364	44,679	800,000	256,186	147	2,770,886
1905 ..	472,504	284,755	147,217	51,877	820,000	281,351	135	3,349,880
1906 ..	365,026	369,408	163,578	62,923	802,290	267,550	142	3,666,274
1907 ..	227,333	417,694	206,910	74,788	833,180	268,992	375	3,455,890
1908 ..	475,267	331,323	121,993	77,864	878,774	314,618	271	3,735,916
1909 ..	474,853	364,662	121,742	66,300	906,782	326,403	280	4,043,730
1910 ..	404,400	515,722	162,990	70,490	1,050,592	345,451	380	4,868,522
1911 ..	651,415	520,120	123,931	86,344	1,189,205	409,682	367	5,389,904
1912 ..	695,240	523,026	191,423	110,921	1,336,755	422,041	658	6,020,902
1913 ..	700,779	500,538	134,293	113,418	1 619,400	663,644	763	6,497,000
1914 ..	—	—	—	—	—	—	—	—
1915 ..	—	—	—	—	—	—	—	—
1916 ..	—	—	—	—	—	—	—	—
1917 ..	—	—	—	—	—	—	—	—
1918 ..	—	—	—	—	—	—	—	—
1919 ..	—	—	—	—	—	—	—	—
1920 ..	20,185	152,015		36,879	460,277	232,110	—	1,750,601
1921 ..	—	—		—	—	—	—	—
1922 ..	102,115	342,292		52,064	512,313	253,754	15,966	2,654,207
1923* ..	62,076	50,024		18,049	197,432	173,378	13,298	1,328,082
1924* ..	46,507	88,134		21,523	242,906	219,657	3,446	1,955,110

* Germany only, after May, 1922.

WILLIAM JACKS & COMPANY,

WINCHESTER HOUSE, OLD BROAD ST., LONDON, E.C.2.

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18, BENNETTS HILL, BIRMINGHAM.
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FOWLERS BUILDINGS, BOMBAY.
CLIVE STREET, CALCUTTA.
ANGAPPA NAICK STREET, MADRAS.

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1, HONG KONG ROAD, SHANGHAI.
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JAVA STREET, KUALA LUMPUR
5, SHAFFRAZ ROAD, RANGOON.
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P.O. BOX 1580, CAIRO.

PIG IRON

SCOTCH, MIDDLESBRO', HEMATITE, BASIC, SPECIALS, &c.,

NON-FERROUS METALS

COPPER, TIN, LEAD, SPELTER, ANTIMONY, CHROME ORE.

WILLIAM COLVIN & COMPANY,

ROYAL EXCHANGE, MIDDLESBROUGH.

93, HOPE STREET, GLASGOW.

SMALL ADVERTISEMENTS.

Notice.

Small Advertisements in this section of the Journal are accepted at the prepaid rate of 6d. per line, first line in capitals counting two, average 7 words per line. Minimum charge for one insertion 3/-.

SITUATIONS VACANT AND WANTED.

CHEMIST and Metallurgist desires change; young; seven years' experience in laboratory, steelworks and foundry; University degree.—Box 438, Offices of THE FOUNDRY TRADE JOURNAL, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

FOUNDRY MANAGER, or Foreman, disengaged, desires position; fifteen years' practical experience of motor-engine castings, specialities, water- and air-cooled cylinders; expert machine moulding, cupola practice; sound technical knowledge of costing, estimating, foundry design; good organiser.—Box 442, Offices of THE FOUNDRY TRADE JOURNAL, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

FOREMAN OR ASSISTANT.—Member of Institute of British Foundrymen seeks position; iron or steel; 39 years of age; technical and practical; can estimate weights and time for work; conversant with machine and sand-slingers; good mixings of compos, oil-sands, facings, loams, etc.; small, medium and large work, all classes; responsible positions since 1912; 13 years one firm; good references as to organising and abilities; moderate salary.—W. BARKER, 136, Nidd Road, Attercliffe, Sheffield.

GENTLEMAN wishes to represent Firm of Scrap-iron Dealers in London; can influence 60/80 tons per week for a start. Replies should state commission offered and also approximate quotation for above quantity.—Box 444, Offices of THE FOUNDRY TRADE JOURNAL, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

FOUNDRY FOREMAN, disengaged, desires position; experienced all branches of engineering and jobbing work, iron and non-ferrous, up-to-date on cupola and mixing of metals by analysis; McLain graduate; good organiser.—Box 424, Offices of THE FOUNDRY TRADE JOURNAL, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

FOUNDRYMAN or Handyman requires position as Cupola Tenter or Assistant (receiver or ordinary cupola), charger, liner, or ladle dauber; in Birmingham or near preferred; strong, willing, married, ex-Service; good references; age 26; eight years' mixed experience.—Box 418, Offices of THE FOUNDRY TRADE JOURNAL, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

FOUNDRY FOREMAN REQUIRED by large firm of Engineers having their own Foundry, all repetition work, only men fully experienced and used to most up-to-date methods of Machine Moulding need apply. Foundry wholly equipped with Denby Hand Jar Ramming Machines. To the right man having the necessary credentials, initiative and push, every opportunity and support will be afforded him. Applications, with fullest particulars and wages required, to Box 446, Offices of THE FOUNDRY TRADE JOURNAL, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

WANTED, by Firm in Midlands, Foreman for Cast-iron Foundry, capable of mixing metals and fixing piecework prices; strong disciplinarian; output about 40 tons per week; general jobbing work, heavy machinery, and light, high-class machined castings.—Box 440, Offices of THE FOUNDRY TRADE JOURNAL, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

PROPERTY.

CHAIN WORKS FOR SALE.
In the North of France, near Calais.

IMPORTANT WORKS FOR THE MANUFACTURE OF FORGED CHAINS for marine work, towage, railway companies, mines, etc. BUILDINGS ARE NEW AND MODERN, with a floor area of over 11,000 square metres, with possibility of extension; complete with railway connection, weigh-bridge, electric swing bridge, and transformers. EQUIPMENT IS COMPLETE WITH LATEST IMPROVEMENTS. The factory is the proprietor of special marks agreed by LLOYD'S REGISTER the VERITAS, and the DEPARTMENT OF ROADS AND BRIDGES. PROSPECTS FOR FUTURE EXCELLENT. Price 1,600,000 French Francs.

Address inquiries, T. TALMANT, 87 Rue de Paris, Pantin (Seine), France.

PATENTS & TRADE MARKS.

PATENT YOUR INVENTIONS, Trade-mark your Goods. Advice, Handbook and Cons. free.—B. T. KING, C.I.M.E. (Regd. Pat. Agent, G.B., U.S.A., and Can.), 146A, Queen Victoria Street, E.C.4. 38 years' refs. 'Phone 682 Central.

THE PROPRIETOR of British Patents Nos. 191875 and 192677 (Div.), both dated November 1, 1921, and both relating to "Improvements in a Foundry Sand Mixer," is desirous of entering into arrangements by way of a licence or otherwise on reasonable terms for the purpose of exploiting the above patents and ensuring their practical working in Great Britain.—All inquiries to be addressed to B. SINGER, Steger Building, Chicago, Illinois.

MACHINERY.

FOR SALE.—20-in. and 24-in. Hall's Invincible Sand Mixers; the original and best machine in the market for mixing old and new Foundry Sand, Coal Dust, etc.—Apply PENNEY & PORTER (ENG.), LTD., Lincoln.

SAND MIXERS.—New and secondhand. Ask us to quote.—W. BREALEY & COMPANY, LTD., Russell Street, Sheffield.

MACHINERY, PLANT, &c.

4 ft. 6-in. RADIAL DRILLING MACHINE, by Fosdick Tool Co., low base, spindle 3¼-in. diam.

New No. 110 CIRCLE CUTTING MACHINE, by J. Rhodes, capacity 60-in. by ½ in.

Nearly New Model S.D. "BECKER" CONTINUOUS TYPE VERTICAL MILLER, spindle 3½ in. diam., all geared head.

Two 40 in. DUPLEX BORING AND TURNING MILLS, by Webster & Bennett, swivel turret heads and gear box-drive.

Two very good dishended LANCASHIRE BOILERS, by Thompson, 30 ft. by 8 ft., reinsure for 140 lbs. per sq. inch working pressure; ready for despatch.

Two LANCASHIRE BOILERS, 30 ft. by 7 ft. 6 in., now insured at 150 lbs. pressure.

CATALOGUE OF STOCK MACHINERY, 6,000 Lots. Free on Application. Inspection Invited.

THOS W. WARD, LTD.,
ALBION WORKS, SHEFFIELD.

MISCELLANEOUS.

"PEERLESS" Core Sand Binder.—Please see our advertisement this Journal, page six, and try a sample; drum or cask.—WILLIAM OLSEN, LIMITED, Hull.

GOGGLES for Foundry workers; light aluminium frames; clear or blue glasses; well ventilated.—LAWSON, WALTON & CO., LTD., Newcastle/Tyne.

The SIR JOHN CASS TECHNICAL INSTITUTE
JEWRY STREET, ALDGATE, E.C.3.
DEPARTMENT OF METALLURGY.

Head of Department ... Geo. PATCHIN, A.R.S.M., M.I.M.M.

The following special courses of instruction will be given during the 1st and 2nd terms (October to March) of the Session 1925-26:—

FOUNDRY PRACTICE. **METALS USED IN THE FOUNDRY**

These courses of lectures, demonstrations and class work accompanied by practical work in moulding and casting, will be given by Geo. PATCHIN, A.R.S.M., M.I.M.M., and A. F. GIBBS, on Monday and Wednesday evenings, commencing Monday, October 5th, 1925.

For details of the courses apply at the Office of the Institute, or by letter to the Principal.

NEW CUPOLA

30" DROP-BOTTOM CUPOLA, by Constructional Co., **new and unused,** with steel charging stage 14'×10'. A bargain, **£65.** Spark arrester and wind belt included; will sell cupola only for **£45.**

NEW LADLES

30 Cwt. EVANS - **£24**
5 Ton EVANS - **£42**

BUY FROM ME AND SAVE MONEY.

ALEX. HAMMOND,
FOUNDRY MACHINERY MERCHANT,
"BOXTED," SLOUGH.